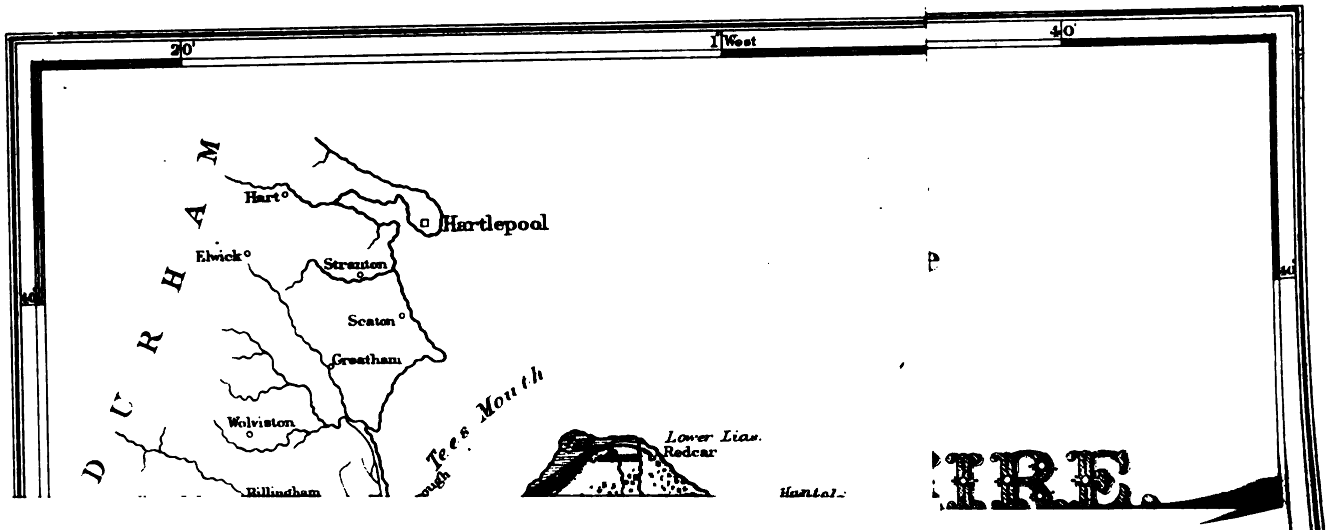
20'
1 West
40'
DURHAM
Hart
Hartlepool
Elwick
Stranton
Seaton
Greatham
Wolviston
Billingham
Tees Mouth
Lower Lias.
Redcar
IRE.

# ILLUSTRATIONS

OF

# THE GEOLOGY OF YORKSHIRE;

OR,

## A DESCRIPTION OF THE STRATA AND ORGANIC REMAINS.

## PART I.—THE YORKSHIRE COAST.

BY

JOHN PHILLIPS, M.A., F.R.S., F.G.S.,

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*THIRD EDITION.*

EDITED BY R. ETHERIDGE.

WITH MAPS AND OTHER ILLUSTRATIONS.

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1875.

"Je ne doute pas, que dans peu d'années peut-être, je ne sois reduit a dire, que l'ouvrage que je termine aujourd'hui, et auquel j'ai consacré tant de travail, ne sera qu'un leger aperçu, qu'un premier coup d'œil jeté sur ces immenses créations des anciens temps."—Cuvier, *Ossemens Fossiles*, tome v. p. 487.

ALERE FLAMMAM.

PRINTED BY TAYLOR AND FRANCIS,
RED LION COURT, FLEET STREET.

To the Memory

OF

WILLIAM SMITH, LL.D.,

WHO SPENT HIS LIFE

IN ESTABLISHING THE

PHILOSOPHICAL PRINCIPLES OF GEOLOGY,

AND IN APPLYING THEM, WHEN ESTABLISHED,

TO PRACTICAL USE,

THIS WORK,

BEGUN UNDER HIS AUSPICES,

IS GRATEFULLY DEDICATED

BY HIS AFFECTIONATE NEPHEW

AND GRATEFUL PUPIL,

JOHN PHILLIPS.

# PREFACE

## TO THE THIRD EDITION.

HALF a century has glided by since the day when, after a visit from York to Kirkdale Cave, I took upon myself the task of preparing such a section of the Yorkshire coast, with figures and descriptions of the organic remains, as might exhibit the strata, from the Lias to the Chalk inclusively, in their true relation to the better known series of the South of England. Previous to 1824 I had, in company with the "Father of English Geology," my uncle, W. Smith, gathered fossils beneath the romantic cliffs which support the Abbey (then almost entire) of Whitby and the Castle of Scarborough. But in that year I had the good fortune to become known to two of the most valuable of all my early friends, Mr. William Bean and Mr. John Williamson, and to profit by their admirable collections of recent and fossil shells, crustacea, echinida, and corals dredged from the neighbouring sea or hammered out of the neighbouring rocks. Then also I began to trust myself as a public lecturer in geology and palæontology, and to employ for illustration the very long section of the cliffs, with measured heights, which in a reduced form, with a few additions and corrections, appears in the present volume.

Before the close of 1828 I found myself in a position to present catalogues of the organic remains from every part of the coast, and to

arrange my numerous drawings of plants, corals, echinodermata, crustacea, and shells in the order proper for their publication. The preparation of the Plates was then a matter of some difficulty. Resolving to employ lithography and to execute every figure with my own hands, my lamp was lighted in the evening, and I occupied all the long winter nights in laborious drawing on stone with pen and ink, a process which had become familiar to me some years before. There being then no lithographic printer at York, Mr. Inchbold undertook successfully the operation at Leeds, and the volume ready in the spring of 1829 was, after supplying many subscribers, placed under the friendly care of Mr. Murray.

For the Second Edition (1835) the Plates were copied in engravings on copper by Messrs. Dawson and Brown, of York. These Plates, corrected in several instances by my old friend Mr. Lowry, have furnished the impressions for this, which must be assumed to be my final edition.

If it should be asked why, after so long an interval of years, it is now thought necessary to call the attention of geologists to a larger description and fuller notices of the fossils of this coast, my reply must run thus:—First, part of the coast once visible is washed away by the sea, which has brought to light new facts of interest; next, some of the descriptions previously made can be enlarged and amended; thirdly, some well-known strata have acquired within a few years a vast commercial importance, especially the ironstones; and, finally, the organic remains have not only been collected in still greater abundance than before, but have in several cases been more scrupulously investigated in regard to their geological habitat. In particular, the so-called diluvial phenomena have been more thoroughly explored, and connected with almost incredible changes of level of sea and land and vicissitudes of climate little dreamed of in 1828 or 1835. Finally, I own to a natural desire that my earliest geological work should be restored to the place in geological opinion which it held on its first appearance: if this could have been done by other hands than mine, I might have been content to lay on younger shoulders the burden of this task; for which,

however, from the date of the earlier edition, I have never ceased to make preparation by renewed personal researches on the coast continued to near the close of 1873.

In some of my latest, as formerly in some of my earliest, examinations of this coast, my companion has been Mr. J. E. Lee, with whom also I have lately repeated an excursion made forty years ago into that part of Lincolnshire which Mr. Judd has lately determined to contain Neocomian strata comparable in age to a part of the Speeton section. We also worked in the Oolitic tract of that county, so important for a right decision as to the age of the Yorkshire Oolites. Professor Williamson has continued the friendly aid experienced from his father; and Mr. W. Gray, with whom I have climbed and measured both cliffs and hills, has supplied some corrections of these measures in East Yorkshire by the latest results of the Trigonometrical Survey.

The public collection at Whitby has been many times opened for my inspection by Mr. Simpson, who has bestowed so much attention on the Liassic fossils; at York Mr. Wakefield assisted my reexaminations in the Museum where I formerly worked; my recollections of many well-known specimens were revived in several visits to the Scarborough Museum; and I owe much to the obliging help of Mr. Keeping in considering the rich drawers in the Woodwardian cabinets at Cambridge.

I add with pleasure and thankfulness that, at the very outset of my design, Mr. Etheridge placed at my disposal his large experience in synonyms; Mr. Gwyn Jeffreys has contributed, what few but himself could attempt with success, a complete revision of the nomenclature of Bridlington fossils; Professor Jones has prepared a Summary of the Oolitic Foraminifera of England; and Mr. Whitaker a careful and laborious Catalogue of Books and Essays relating to the Geology of Yorkshire. Other acknowledgments of help, both kind and effectual, will be found in the body of the Work.

If, after all, it should occur to any reader that, forgetful of advan-

cing years, I have undertaken a task which should have been left for others,

> . . . . . . . . quibus integer ævi
> Sanguis, et solidæ suo stant robore vires,

I reply that, before encountering the labour of producing what in effect is a new and much enlarged volume on the Yorkshire coast, I was assured of the hearty cooperation of the two palæontologists who, by their residence at Scarborough and their untiring study of the fossils of the vicinity, were the most competent of all men to give effectual help, Mr. Leckenby and Dr. Lycett. To them, therefore, not my thanks only, but those of all geologists who feel an interest in the peculiar series of plants and animals whose remains enrich the mesozoic strata of Yorkshire, are especially due.

The Yorkshire coast has ever been my delight: to sketch its romantic promontories, to climb and to measure its cliffs, to investigate its numerous fossils and its rich variety of marine life may be recommended to every lover of natural beauty and to every student of natural history. To them I bequeath what has been to me a labour of love, a life-long enjoyment—the study of the great Mesozoic Section here so plainly cut,—not doubting that kindly thoughts will accompany the corrections and additions which time has brought and still must bring to the work which I now consign to their use.

Oxford, 1st May, 1874.

# EDITOR'S PREFACE.

THE sudden death of Professor Phillips when he had nearly completed this Third Edition of his Geology of the Yorkshire Coast, of necessity retarded its issue. Shortly after his removal I wrote to Messrs. Taylor and Francis, offering to assist any one who would aid in the somewhat anxious undertaking, and complete the work that distinguished geologist had so far left undone. Some time elapsed and no one came forward to take it up as Phillips had left it: when, however, it was necessary that his valuable Library, Collection, and Philosophical Instruments should be distributed and the estate realized, certain letters, bearing much upon the new edition, came into the possession of W. Smith, Esq., of Cheltenham, cousin and executor to the late Professor; these, with my offer to complete the book, met with his approval, and he at once intrusted the completion to me; this also met with the approval of Messrs. Taylor and Francis, and also that of Prof. Prestwich, Phillips's successor to the chair of Geology in the University of Oxford. For many years I had given much attention to the Eastern part of Yorkshire, and on many occasions Professor Phillips consulted with me upon the many changes in his new edition; and the new nomenclature he has adopted for the organic remains is that which I had rendered to, and corrected for, him not long before his death. I therefore felt anxious to see his work completed and issued, nearly, I believe, as he would have done had he lived. I have had 3500 Plates of sections coloured, and have also added a new Geological Map of the Eastern part of Yorkshire. This Map is part of the general one issued by Professor Phillips in 1853. The

Map has been relithographed and recoloured especially for this edition, feeling that this would materially add to the usefulness and value of Prof. Phillips's work—especially so, as the Map above named (1853) was his own, and embodied his then latest views upon the geology of the eastern area. I knew that Phillips intended adding a new map to his new edition, and therefore believed it better to make use of that portion illustrating the range of his present work. I have made those changes needed to render the nomenclature that now adopted. I have to thank W. Smith, Esq., for his ready assent to all matters connected with the expense attendant upon the preparation of the Map and Sections (indeed all that part intrusted to me to finish), and his desire to see this last labour of Professor Phillips's, and also his first and earliest work, completed and given to the world.

R. ETHERIDGE.

Royal School of Mines, 28 Jermyn Street,
June 1875.

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# CHAPTER I.

## SERIES OF YORKSHIRE STRATA: SILURIAN AND CARBONIFEROUS ROCKS, COAL.

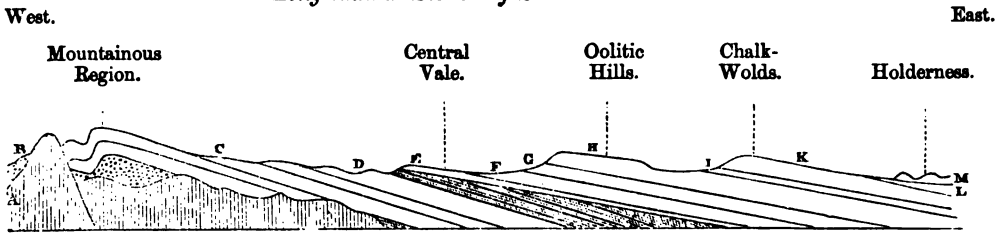
YORKSHIRE is one of the few counties of England which are defined by natural boundaries. On the west it reaches, and in some places extends beyond, the great summit ridge of the island; the Tees is its natural limit on the north, the Dun for a great length on the south, and on the east it is washed by the German Ocean. Its area is divided into several obvious sections, distinguished alike by topographical features and geological structure. Along the middle of the county, from north to south, runs a wide level vale, filled with gravel, deposited on the New Red Sandstone, Red Marl, and Lias. From beneath rises towards the west an elevated undulated tract of carboniferous and calcareous rocks, which ascend to the summits of Micklefell, Ingleborough, and Pendle Hill; whilst above, on the east, appear the more uniform ranges of the Chalk and Oolite. The hilly western tract is grouped in two portions,—the district south of the Aire, in which, generally, sandstones and shales with coal abound; and the more elevated region north of that river, whose romantic dales are sunk into the Mountain-limestone, and whose picturesque hills are capped by Millstone-grit and the lower members of the coal series.

No other English county, hardly any other natural district in Europe, exhibits, within so moderate a compass, as large a proportion of the fossiliferous strata; for its scale of ancient life extends almost continuously from the Silurian rocks to the Chalk, and admits small tracts of shelly beds allied to the Crag, and broad spaces of glacial drift, besides marine and freshwater deposits rich in remains of Pleistocene age.

The diagram which follows will show the main features of the physical

geography of Yorkshire in relation to the successive strata, which, on the whole, are inclined to the eastward.

*Longitudinal Section of Strata in Yorkshire.*

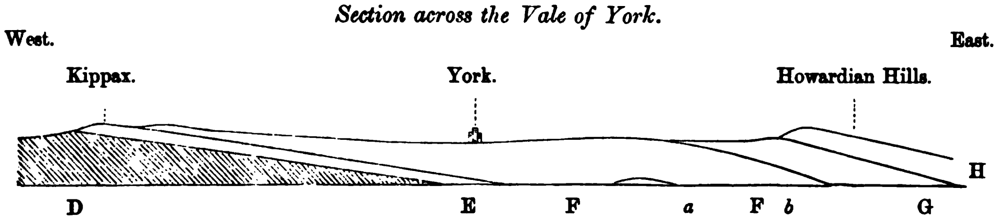



Line of half a mile depth below the sea-level.

A. Silurian (unconformity here). B. Old Red (irregular). C. Mountain-limestone (including whinsill, marked W, page 3) and Millstone-grit. D. Coal-measures, hardly apparent at the surface in the northern parts of the county. E. Magnesian and other Permian strata. F. New Red. G. Lias, with ironstone (*i*′, page 3). H. Oolitic system, with ironstone (*i*″, page 3). I. Speeton Clay. K. Chalk. L. Supposed Crag (very limited). M. Pleistocene deposits.

By considering several lines of section, the succession of strata here sketched can be perfectly verified. On no one line do they all appear with equal distinctness. In thickness, all probably vary much; but this is especially to be remarked in the groups of Mountain-limestone and the oolites, which, in this region, admit many masses of sandstones and shales, with coal and ironstone of limited extent and great inequality of thickness. This is so remarkable in Yorkshire as to replace the purely calcareous masses of Derbyshire limestone and Lincolnshire oolite with very complicated groups, resembling coal-fields, and in fact yielding workable coal. On the next page the Yorkshire groups of strata are placed in their true relations of superposition and thickness.

*Section across the Vale of York.*




Line at a depth of 1500 feet.

D. Coal-measures, supposed to extend below the Vale of York. E. Permian strata.
F. New Red. *a.* Sandstone. *b.* Marl. G. Lias. H. Oolite.

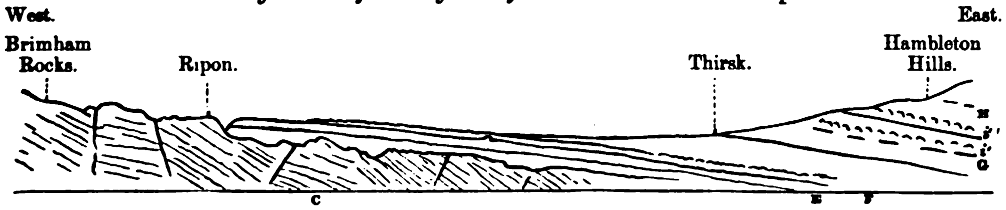
*General View of the succession and relative thickness of the principal Groups of Strata in Yorkshire.*

| Era | System | Group | Letter | feet. | Locality |
|---|---|---|---|---|---|
| CAINOZOIC | | Pleistocene | M | 250. | Holderness. |
| | | Crag? | L | 10. | Bridlington shore. |
| MESOZOIC | | Chalk | K | 600. | The Wolds. |
| | | Neocomian | I | 350. | Speeton Cliff. |
| | | Oolitic | H | 1500. | Malton, Scarborough. |
| | | | i'' | | |
| | | | i' | | |
| | | Lias | G | 850. | Whitby, Cleveland. |
| | | New Red | F | 1000. | Vale of York. |
| PALÆOZOIC | | Permian | E | 250. | Knaresborough. |
| | Carboniferous System. | Coal-measures | D | 3600. | Leeds, Barnsley, Sheffield. |
| | | Millstone-grit and Mountain-limestone | C W | 3000. | Swaledale, Yoredale, Wharfdale. |
| | | Old Red | B | | |
| | | Silurian | A | Thickness unknown. | Ribblesdale, Ingleton. |

The total thickness of the Yorkshire strata above the Silurian rocks may be taken at about two miles, of which the Palæozoic strata occupy two thirds. The Carboniferous strata are all found in greatest mass on the south-western border; they become even twice as thick in the Lancashire and Cheshire district; but through Derbyshire on the south and Durham on the north the analogy with Yorkshire is maintained in this respect.

The description of the mountainous region west of the Vale of York, composed of Palæozoic rocks, is given in a separate volume; but some remarks are here necessary to show the true relation of the Carboniferous system there exhibited with the Mesozoic strata which overlie them in the Vale of York, and constitute the eastern hills, vales, and coast, which are the principal subject of the following pages.

*Section across the northern part of the Vale of York, anciently called Vale of Mowbray, showing Carboniferous system of Strata at considerable depth.*




Line at a depth of 1500 feet below sea-level.

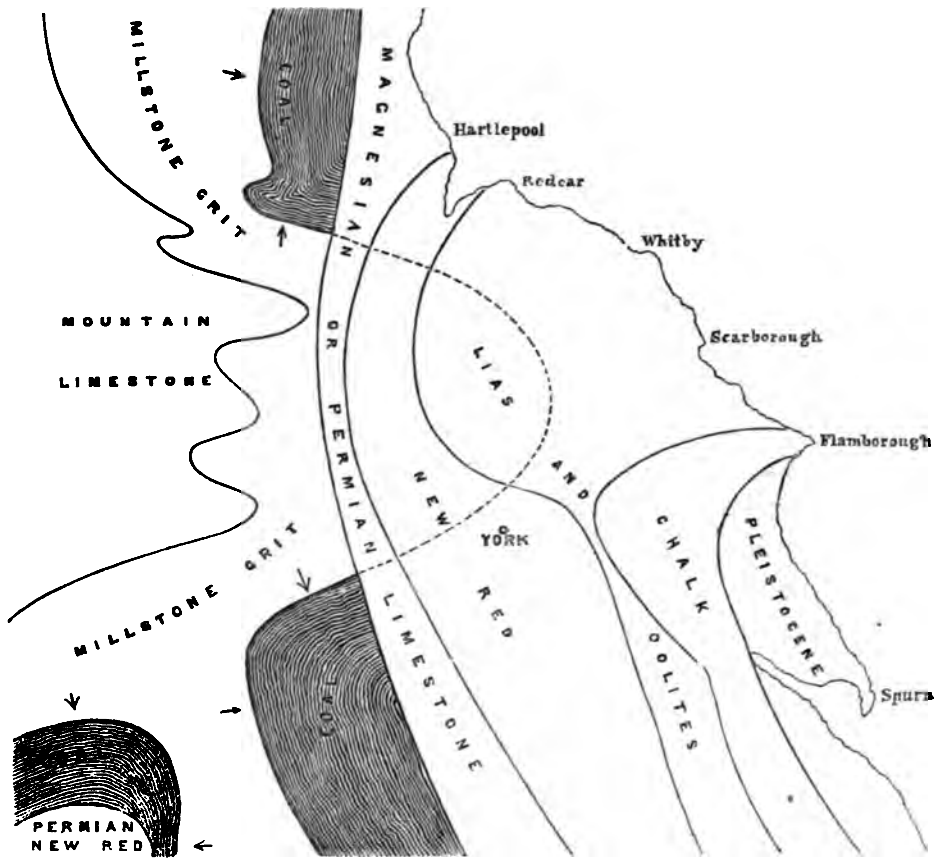
C. Strata of the Mountain-limestone series, partly Yoredale rocks, at Middleton Tyas, partly Millstone-grit, as near Ripon, no true Coal-measures (D) being visible at the surface. E. Permian strata. F. New Red formation. G. Lias, with ironstone, i', included, and marlstone below it. H. Oolite, with ironstone, i'', at the base.

One of the most remarkable features in the geological topography of Britain is the irregular ramification of the hilly Carboniferous system; for this is so wrinkled by ridges and hollows, and broken into islands, as to justify, on a first view, the popular idea of coal being found in separate basins. This is true in some instances: but for many large tracts a more comprehensive, if not a better explanation is to be sought; for, without doubt, the great tracts of Millstone-grit and Lower Coal-measures in the north of England were all deposited on one general floor of ocean-born limestone; they are, in fact, still connected from Northumberland, through Durham and Yorkshire, to Lancashire, Derbyshire, and Cheshire; and coal laid parallel to the other strata occurs in all parts of the series of

Mountain-limestone and Millstone-grit, commonly in the north, though rarely in the south.

The interruptions at the surface, between the Lancashire and Yorkshire coal-fields, are quite consistent with the conviction of the former continuity of these deposits, their actual separation being due to anticlinal movements and faults, followed by great denudation, a common and well-understood occurrence. A case of much practical importance arises for consideration in the actual separation at the surface of the coal-fields of Durham and Yorkshire; for this separation is accompanied by circumstances which suggest the reunion of the two branches below the later strata which fill the Vale of York, though the interval between them at the surface is about fifty miles.

*Diagram Map.*



To understand this case, let the diagram (p. 5) be regarded as a generalized map of the distribution of the principal stratified masses, and compared with the section on p. 2. The remarkable line marking the unconformed superposition of the Magnesian Limestone first catches attention; for this cuts off alike the limestone, grit, and coal, the two former constituting a kind of irregular and broken wedge between the coal-fields, which both deviate from their ordinary north and south course, and turn eastward in conformity with the general anticlinal movement. The surfaces of deposition are greatly undulated, and the whole area west of the Magnesian Limestone is broken by faults and wasted by denudation. There is no reason to deny the continuation of these characteristics under the later strata. Covering all this undulated, broken, and abraded surface, then, with some inequality of thickness and other irregularities, the later strata lie with almost uniform gentle dip eastward; and no boring has yet been made entirely through them, so as to discover what is buried beneath.

Geology is appealed to for encouragement to make the experiment, to sink for coal at some well-chosen spot, in the region lying eastward of the boundary; and some incomplete trials have been made without much consideration of the problem to be solved. One of them began and ended in the Lias at Gromont, near Whitby, a point about thirty miles eastward of the Durham coal-field, as at present known. Had it been carried to a sufficient depth, it might have given useful and even important information. Borings at Middlesborough, Kirk Leavington, and Middleton-one-Row, in New Red and Permian beds, have yielded salt, gypsum, and sulphurous waters; another experiment east of Richmond passed through New Red and Permian beds, at Easingwold the Lower Lias was explored two or three hundred feet, at York the New Red series to a depth of 600 feet, and at Reedness, near Goole, 1029 feet.

These trials, which in some cases ended where they ought to have begun, are quite inconclusive; yet they have assured us of the approximate truth of the estimates of thickness of the strata which overlie the coal. We must not expect to touch the Palæozoic strata until 1500 feet of New Red and Permian rocks be traversed. This, in the actual state of mining-operations, is an easy task. When accomplished, we may

become anxious to know what part of the Carboniferous system is likely to be found; at present we may calmly weigh the probabilities, and determine the most favourable points for judicious trial.

To take the most encouraging view, let the eastward or south-eastward strike of the Durham coal be prolonged toward Guisborough and Whitby, and the eastward or north-eastward strike of the Yorkshire field be continued toward York and Scarborough; and let both be connected by a curve concave to the west. It must be outside of this loop that experiments should be tried. This space is narrow on the northern side, if we are to begin on the New Red marls; wider on the southern side. On the whole, the most advisable point for a first trial is at some point south or south-west of York, where it is not unlikely that a boring to the depth of 1500 or 2000 feet might have a favourable issue; since the beds of coal are known to preserve their thickness and quality as they pass eastward from Leeds to Garforth and Aberford, and there is no reason to fear a rapid deterioration. But is the day arrived when such a trial is to be recommended so near to the productive coal-field now in prosperous union with railways and ironworks?

Trials for coal, in this and other situations far removed from existing collieries, will probably be undertaken with less rashness than heretofore, now that geology has been listened to by the Royal Commission on the extent and duration of our coal-fields. It may be expected that the requisite cost and depth of the sinking, as well as the general probability of a favourable result, will be submitted to serious consideration before experiments of such great public importance should be commenced; it may be hoped that they will not be left to the caprice of individual landowners or speculative adventurers, but taken up thoughtfully and resolutely, as work for a county rather than a parish, with ample resources to continue the process for some years, so as to reach a depth of at least 2000 feet with instruments of sufficient size to leave no doubt of the nature of the rocks penetrated.

# CHAPTER II.

## THE VALE OF YORK: PLEISTOCENE, PERMIAN, TRIASSIC, AND LIASSIC DEPOSITS.

IF the land were depressed 250 feet, York Minster would be under the waves; the sea would ebb and flow in a long and broad channel uniting the vale of the Ouse with that of the Trent, and receiving on the west the shortened streams of the Tees, Swale, Yore, Nid, Wharfe, Aire, and Dun, all historically notable rivers. Eastward, the Derwent valley would become a narrow winding strait leading to a marine expansion in the Vale of Pickering, the wolds would be insulated cliffs of chalk, the heathy northern moorlands a prominent sea-beaten mass of oolitic and arenaceous rocks.

The changes here supposed have really occurred twice since the main features of physical geography were sketched in Yorkshire,—once on the rising of the glacial waters, and once on their retiring. But the height of these waters was much greater; probably they were so deep as to overwhelm alike chalk-wolds and oolitic moorlands, even to the submersion of their highest points. As a natural consequence, the Vale of York and the adjacent slopes, but not, as far as is known, the highest summits, are strewed with irregular accumulations of gravel, sand, and clay, brought down to the vale by glaciers, or drifted on the backs of icebergs; and in them occur remains of mammoth, hippopotamus, rhinoceros, bear, and other inhabitants of the region—to which, so far as we know, man had not then brought his colonies from the far east.

The diagram Map (see p. 9) shows in a general manner the small extent and scattered distribution of land in this part of Britain during the glacial period, and by means of lines represents movement either of solid land ice or floating icebergs, or both; for these are cognate phenomena. The drawing of these lines is entirely from my own observation, which, at an early period in my geological studies, was specially directed to the occurrence of far-travelled blocks of Shap-fell granite and other rocks of the Lake-district, which are scattered over large spaces in


C. Cheviot.
Cr. Criffel.
P. Carrock Pike.
S. Shap fell.
C. F. Cross fell.
M. F. Mickle fell.
I. Ingleborough.
P. H. Pendle Hill.
M. Holme Moss.
K. Kinderscout.
X. Axe Edge.
Ty. Tyne River.
T. Tees River.
W. Whitby.
Sc. Scarborough.
F. Flamborough Head.
H. Humber.
B. Burton Head.
Y. York.

every direction but one, viz. to the west. A stream of syenitic rocks has come eastward and southward from Criffel in Galloway to the northern parts of the Lake mountains; from the high region of Eskdale in Cumberland granite has been carried into the plains of Lancashire and Cheshire; Helvellyn and Carrock Pike have given rocks which have accompanied the Shap granite round the northern end of the Pennine Chain, and over the pass of Stainmoor, from which they diverge towards the coasts of Durham and Yorkshire. A long and broad stream of erratics from Shap and the region of Scar fell has gone southward to beyond Manchester.

Three facts connected with this extensive distribution deserve special attention. First, on the eastward slopes of the granitic mass of Shap fell lie countless blocks derived from the summit, of all sizes below 40 tons, unworn except by atmospheric vicissitudes. Secondly, these radiating streams have left traces in the deep and broad Vale of Eden, but in general cease against the high crest of the Pennine limestones and grit-stones: to this there is one exception; for through a broad pass in that crest, at Stainmoor, lying due east of Shap fell, the blocks have gone, in great numbers and of large size, to Barnard Castle, Darlington, the vicinity of Stokesley, Thirsk, and York, and have even reached the sea-coast near Whitby, Scarborough, and Flamborough. Thirdly, in all this region, and generally in the tract of drift lying about Lancaster and Manchester, the erratic blocks of several Cumbrian rocks lie at or near the surface, and seem to be monuments of the latest of the great ice-currents which moved at elevations reaching 800, 1000, and 1500 feet in some parts of the north of England*.

The PLEISTOCENE accumulations which cover the Red-Sandstone deposit in the Vale of York consist generally of great quantities of gravel and fragments of rocks derived from the west and north-west of Yorkshire, intermixed with others from the Cumbrian mountains. The relative proportion of stones derived from the latter source increases from York northward; so that in the gravel near Easingwold, Thirsk, North Allerton, and Stokesley a great variety of specimens of rocks may be col-

* Some of these blocks have been collected in the vicinity of York and Scarborough, and placed or preservation in the grounds attached to the Museum at York.

lected, such as occur about Grasmere, and Patterdale, Kirby Stephen, Shap fells, Carrock fell, and High Pike. There is to be observed, generally, in the Vale of York a distinction of these deposits into three kinds,—one argillaceous and holding a larger proportion of pebbles and slightly worn fragments of rocks brought from very distant sources; another a sandy and gravelly deposit in which masses of sandstone and limestone from the western regions are more predominant; the third a mass of rounded chalk and angular flint. Near York, and along the line of country to the north-west, the gravel consists principally of sandstones and limestones from the western hills; sometimes sandstone occurs almost alone (Ouseburn); sometimes a mixture of sandstone, limestone, basalt, granite of Shap, &c. (near Boroughbridge). As we proceed toward Doncaster and the Vale of the Trent, the drift consists of materials from the west, and is found to contain very few traces of that impulse which brought the Cumbrian rocks over Stainmoor, and spread them across the whole north-east of Yorkshire and along the coast of Holderness. The numerous excavations for the roads have laid open the second sort of accumulation more frequently and completely than the others, and a considerable number of bones and teeth of the mammoth, rhinoceros, bear, large ox, deer, horse, &c. have been discovered in it. The elevation of the undulated ground formed by these accumulations in the middle of the Vale of York is inconsiderable, seldom exceeding 70 or 100 feet; but portions of similar deposits rest on higher points toward the Hambletons, and lie in high valleys of the wolds (as at Middleton).

In some places (Sandburn near York, Ouseburn, &c.) indications of lacustrine deposits may be observed resting on the gravelly and boulder accumulations, and containing wood, freshwater shells, &c. as in Holderness; so that there can be no doubt of the similarity and, geologically speaking, contemporaneity of origin of all the deposits classed as Pleistocene in the northern and eastern parts of Yorkshire. Along the western base of the chalk-wolds, about Pocklington, Market Weighton, &c., are limited breadths of the third sort of drifted deposits, consisting of chalk and flint spreading over the Lias and New Red Sandstone, and apparently due to local though very powerful currents; but whether contemporaneous with those which laid the similar gravel amidst the

ordinary boulder-clay of Holderness, or beneath it at Hessle, is difficult to pronounce. On the sea-coast near Bridlington several situations will be noted which show the diluvial currents to have been of some duration, subject to vary in impetus and direction, and to be interrupted at intervals of at least local tranquillity. In such a period of partial tranquillity we may believe the laminated clays at Ouseburn and Kilnsea to have been deposited; and a more interesting discovery of the same nature in the Vale of York in 1829 appears to indicate that such intervals in the glacial period may hereafter become distinctly characterized by peculiar deposits and contribute to correct the general history of the formation.

BIELBECKS.—The merit of first calling attention to the ossiferous marl deposit of Bielbecks near Market Weighton belongs, in a great degree, to Mr. William Hey Dikes, of Hull, who, after a careful study of the circumstances of this deposit, favoured me with the information which he had collected. I lost no time in proposing to my friends, the Rev. W. V. Harcourt and Mr. Salmond, an excursion to the locality; and our joint communication on the subject was inserted in the 'Philosophical Magazine' for Sept. 1829. Subsequently the great importance of the facts connected with this discovery induced the Council of the Yorkshire Philosophical Society to continue for the advantage of science the excavations which the farmer had originally made for agricultural purposes, and a great number of additional bones were discovered; the geological circumstances connected with them were fully ascertained, and made public by a second Memoir of Mr. Harcourt (Philosophical Magazine, 1830). The whole collection of bones, and many of the accompanying shells, &c., were subsequently placed in the Yorkshire Museum by the liberality of the proprietor of the land, W. Worsley, Esq., of Hovingham, and there this unique collection is carefully labelled and arranged.

The following is an epitome of the facts observed and recorded. The Market-Weighton Canal passes through a part of those extensive levels or flat alluvial tracts which border the tide-rivers of Yorkshire, and consist of silt deposited by the tides and freshes, variously interspersed with tracts of peat moor and accumulations of timber, and divided by

insular hills and ranges of "hard land." From the Humber to the country near North Cliff, Market Weighton, and Holme no exposure of stratified rocks is anywhere observed, nor any very obvious indication of diluvial accumulations. The south-eastward base of the gravel hill of Holme shows Red Marl and Gypsum, the lower part of the Lias appears at North Cliff, three miles to the east, and the intermediate country is nearly an unbroken flat, a few feet above high water in the Humber, of sand, peat, and silt land, with an irregular border of chalk and flint and other gravel on the east, constituting the very low talus of the Lias range of North Cliff and Hotham. That nearly the whole is underlain by the Red Marl and Gypsum is evident by the exposure of these substances in the Market-Weighton Canal and by the observations to be noticed.

Two miles south of Market Weighton, and one mile north-west of North Cliff, at the edge of a sandy and gravelly warren, in the eastern part of the broad level above described, is the solitary farmhouse of Bielbecks, belonging to Wm. Worsley, Esq. The tenant, Mr. Foster, desirous of improving the poor sand land near the house, opened a considerable deposit of argillaceous marl, and spread it in great quantities on his fields.

The excavations presented the following section above the water:—

| | ft. | in. |
|---|---|---|
| 1. Black sand at the surface . . . . . . . . . . . . | 0 | 9 |
| 2. Yellow sand . . . . . . . . . . . . . . . . . . | 1 | 6 |
| 3. White gravel, consisting of small pebbles of chalk and angular fragments of flint, with a few pieces of *Gryphæa incurva* and fewer pebbles of sandstone, varying in thickness, average . | 2 | 6 |
| 4. Blue marl, irregularly penetrated by gravel (No. 3) and partially chequered by it . . . . . . . . . . . . | 5 | 0 |
| 5. Commencement of a blacker marl which had been excavated to a depth of 10 feet, and contained most of the bones and shells. | | |

Under the direction of Mr. Harcourt another pit was opened; six or seven hundred loads of marl were removed, the deposit was penetrated to its lowest bed, the depth at which the several bones were found was measured, and the nature and the mode of occurrence of all the contents of the pit were carefully observed. The following Table, drawn up by

Mr. Harcourt, contains the chief details of this examination; the bones and shells were identified by myself:—

| MINERAL CONTENTS. | Depth in feet. | ORGANIC CONTENTS. |
|---|---|---|
| *Yellow sand.* In this and the gravel below it a few pebbles of quartz and sandstone. | 3 | No bones, shells, or vegetable remains in the sand or gravel. |
| *Gravel* composed of chalk pebbles and sharp flints. | 4½ | |
| *Grey marl* indented by the gravel in some places to the depth of 3 feet, and containing rolled pebbles of quartz, mountain-limestone, and sandstone of the carboniferous series, with chalk and flint. | 10 | No shells or vegetable remains in the gray marl.<br>ft.<br>At 7 *Elephas primigenius.* Numerous small fragments of the tusk and teeth.<br>8 Calcaneum of ditto.<br>9 Three cervical vertebræ of ditto.<br>10 Astragalus of ditto; radius of *horse,* lower end; radius of *rhinoceros,* upper end; branch of horn of *deer.* |
| *Black marl,* containing minute pebbles of chalk, very few flints; at the bottom two or three pieces of a fine-grained calcareous sandstone, similar specimens to which may be found in one of the adjacent beds of the red-marl series; no fragments derived from remote districts. | 22½ | 11 *Bison.* Metatarsal bone.<br>*Wolf.* Radius.<br>12½ *Elephant.* Humerus, and the head of it detached.<br>13 *Horse.* First phalangeal bone.<br>13½ *Ditto.* Second ditto.<br>14 *Ditto.* Third (with *Helix nemoralis*).<br>*Elephant.* Four caudal vertebræ.<br>*Duck.* Ulna, clavicle, tibiæ.<br>15 *Bison.* Occiput, horns, and part of the frontal and maxillary bones.<br>*Wolf.* The right lower jaw, and condyle of the other; *right humerus, radius, and ulna articulating.*<br>18 *Bison.* Two molar teeth of the upper jaw.<br>The black marl abounds in shells, chiefly *Planorbis complanatus* and *Limnæa palustris,* and in vegetable remains, including jointed stems.<br>*Horse.* A rib. |
| *Strong blue marl.* Some clay nodules in this.<br>*Flint gravel in marl.*<br>*Strong blue marl.*<br>*Flint gravel in marl.* | | No bones, shells, or vegetable remains in these alternations. |

RED MARL the basis of the whole deposit.

The basin of red marl in which this lacustrine deposit is formed is very limited, only a few hundred yards long from east to west, and not so much from north to south; the black ossiferous and shelly marl appears, by Mr. Harcourt's borings, to be in one place only about 50 or 60 yards across in the direction from north to south. About a quarter of a mile to the east is another marl deposit, covered by five or six feet of chalk and flint gravel; half a mile further in the same direction is another consisting of a stronger blue clay, in which much undecomposed *shale* may be observed, enveloping in its upper part *boulders* of the Chalk, blue Oolite, and Lias of the neighbouring hills.

*Condition of the Bones.*—Among the numerous specimens of bone, very few showed the least mark of mechanical attrition or chemical decomposition; in general they were perfectly preserved, and many of them entire; such as were broken showed uninjured surfaces and angles of fracture. On *the ends* and edges of two of the broken bones there was a high polish; a peculiar corrosion into little pits was observed on one or two fragments; the epiphyses of the vertebræ of the elephant (it being a young individual) were found nearly in their relative place; and the same remark applies to the metatarsal and phalangeal bones of the horse, and to the leg-bones of the wolf. Upon the whole nothing can be more certain than that the bones in the black marl were inhumed only a very small distance from the place where the animals died, that they had not been subject to the ravenous jaws of hyænas, nor been transported from any earlier deposit.

The following species of animals were recognized:—

| | |
|---|---|
| REMAINS OF QUADRUPEDS. | These were found both in the black marl and in the superior marly gravel deposits. |
| *Elephant* (Elephas primigenius, *Blum.*). | Tusk, teeth, humerus, and vertebræ. |
| *Rhinoceros tichorhinus* . . | Teeth, tibiæ, rib (?). |
| *Bison priscus* . . . . | Cranium and horns, teeth, vertebræ, bones of the legs and feet. Parts of two individuals were recognized. |
| *Stag* of great size . . . | Portions of horn and metatarsal bone. |
| *Horse* of large size . . . | Metatarsal and phalangeal bones of the hind leg. |

| | |
|---|---|
| *Felis spelæa* . . . . . | Lower jaw, part of upper jaw, femur, radius, ulna, and metacarpal bones. |
| *Wolf* . . . . . . . | Humerus, radius, and ulna of right side, right lower jaw, condyle of the other. |
| BIRDS: *Duck* . . . . | Ulna, clavicle, tibia. |
| INSECTS . . . . . . | The green elytron of a species of *Chrysomela*. |
| MOLLUSCA . . . . . | The remains of this class were numerous in the black marl, but did not occur in any other member of the deposit. They consisted of thirteen species, all identical with living types procured in the neighbouring country, viz.:— |
| Three TERRESTRIAL SHELLS. | *Helix nemoralis*, four specimens marked with coloured bands; the rufous tint, though faded, is still distinguishable. On three of them are three bands on the upper whorls, on the other two. |
| | —— *caperata*, two specimens. |
| | *Pupa marginata*, three specimens. |
| One SWAMP SHELL . . . | *Succinea amphibia*, Drap., three specimens. |
| Nine FRESHWATER SHELLS. | *Limnæa limosa*, one specimen. |
| | —— *palustris*, fifteen specimens, varying like the recent examples in proportion and degree of smoothness, but never bevelled in the upper part of the volution; the twist on the pillar-lip is perhaps a little more decided and prominent. There is one specimen of a very remarkable variety, shaped like *L. longiscata* of Lamarck, but marked with facets like the other specimens of *L. palustris*. |
| | *Planorbis complanatus*, twenty-three specimens. I can find no other difference between these and those now living near York than the rather more frequent occurrence of spiral striæ across the lines of growth. The same varieties as to flatness of the whorls and position of the keel as in fresh specimens. |
| | —— *vortex*, one. |
| | —— *contortus*, two. |
| | —— *nitidus*. |
| | —— *spirorbis*, one. |
| | *Valvata cristata*, one. |
| | *Pisidium amnicum*, five. |

The shells are all white, never compressed, not particularly tender, and very entire. The black marl which contains them is not laminated; nor are the shells arranged in it in any peculiar order or position, but lay mixed with bones from top to bottom indifferently. It was doubtless deposited beneath the waters of a marshy pool, which nourished the *Planorbes*, *Limnææ*, &c., and received by some little streamlet, or occasional inundations, the *Helices* from the land, and *Succineæ* from the adjoining plants. The elephant, rhinoceros, and other animals died near the lake or the stream; and their partly disintegrated remains were washed by the same gentle subaërial forces into the same repository, or brought thither at a later period, along with abundance of marl and gravel, attesting the operation of a more powerful and considerable current of water. By these latter accumulations the lake was filled to the level of the surrounding surface.

In this lacustrine deposit of the mammoth era are observed facts of great value towards elucidating some material points regarding the early condition of Yorkshire.

*First.* Since all or nearly all the mass of clay and marl and chalk and flint-gravel may be reasonably admitted to have been brought from the neighbouring low ranges of Lias and the surface of the wolds, there is nothing to indicate the operation of floods of extraordinary power or extent, except the presence of some pebbles of limestone and sandstone derived from the western hills, which lie in the upper parts of the deposit. These are few in number compared to the mass of flint and chalk gravel, and, though requiring the admission of the flowing of rivers or other currents from the west, do not demand for the explanation of their accumulation *here*, more than the action of such limited floods or inundations as might deposit the rest of the gravel. Such inundations were frequent *before* the deposition of the ossiferous marl, and were repeated at a later period; and it appears to be proved, both by comparison with the analogous deposits at Hessle and Bridlington, and by the superposition of the ordinary "diluvium" in the south-eastern part of the Vale of York, that the *latest* of these inundations was *anterior* to the movement of waters

which brought many Cumbrian rocks through the pass of Stainmoor, and dispersed them over the hills and valleys and antediluvial lake-deposits of Yorkshire. *How long anterior* is not the question; the order of succession of the events is all that we are now concerned with.

*Secondly*. It follows from what has been stated, as to the limited nature of the agencies concerned, that the quadrupedal, molluscous, and other remains are those of animals then living in the vicinity; and this conclusion is amply confirmed by the condition of these reliquiæ. This important truth, no longer depending solely on the evidence, however satisfactory, in Kirkdale Cave, but attested by new witnesses, may be definitively admitted; and we are enabled to clear those parts of geological theory which relate to comparatively recent operations on the surface of some objections, and to propose a precise and logical argument concerning the ancient condition of Yorkshire.

We may be sure that the leading geographical features of the south-eastern parts of the county are of higher antiquity than the date of the glacial floods. Though certainly particular tracts were greatly devastated by these waters, and their wasted materials carried in a strange manner to great distances, the physical aspect of this particular region was only modified in a slight degree—the fundamental features of hill and valley were unchanged, the course of drainage was little affected, the races of aquatic animals were not destroyed; the devastation passed, and with it apparently perished the larger and heavier quadrupeds of the marshes and plains; but many races survived, to perish in later days by natural changes or man's persecution—inhumed in similar lakes with similar shells, in various parts of the county.

The question of ancient climate receives from this investigation new and independent data. While from the general *analogies* of form between the fossil and recent elephant, rhinoceros, hippopotamus, felis, and hyæna, the mind was influenced by a vague notion that the climate of the northern zones was formerly of a tropical character, the equally strong analogies of the urus, glutton, beaver, wolf, deer, &c. restored the

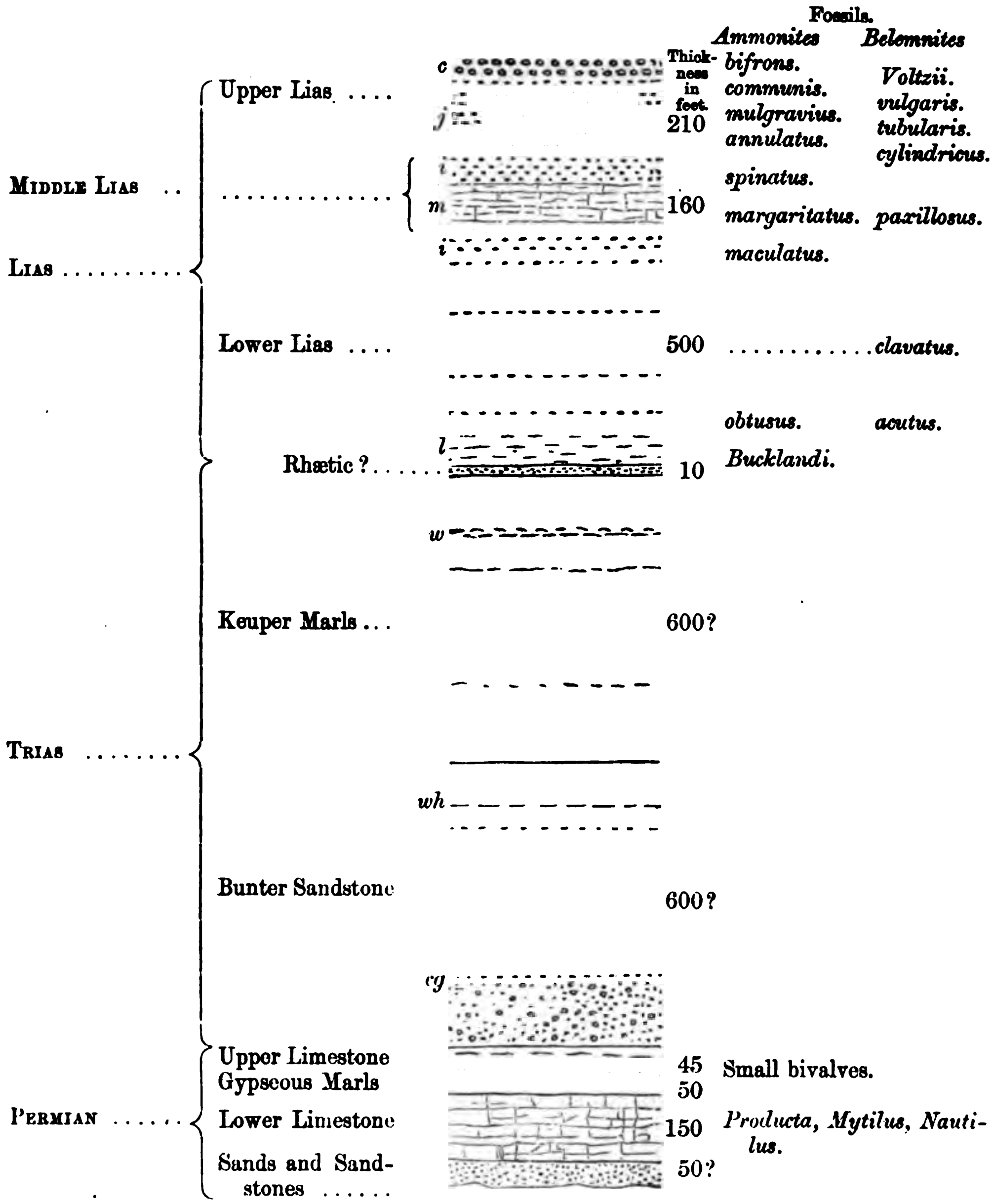
balance of opinion, and geologists were not justified in coming to a positive conclusion. But the occurrence with the elephant and rhinoceros of thirteen species of land and freshwater shells precisely *identical* with existing types from the neighbouring pools and ditches, must be allowed to give more exact and satisfactory evidence. Such a group of molluscous animals does not exist together, except in a small range of latitude, to the north or south of England: before arriving at the parallel of 60° N. many of the species are lost; others vanish and are replaced by new forms before we touch the shores of the Mediterranean. Such, then, are the limits within which speculations as to the ancient climate of the northern regions once tenanted by the elephant and rhinoceros must be restrained; and those who recollect the hairy covering of the individuals of these genera found on the shores of the Arctic Sea will probably supply for themselves the obvious conclusion that these animals were fitted by a peculiarity of constitution to support at least the occasional rigours of a temperate climate.

Existing species of freshwater shells occurring in connexion with extinct fossil quadrupeds have been noticed by Mr. Hugh E. Strickland, under beds of gravel near Cropthorne in Worcestershire; they occur frequently in postglacial gravels and clays in the valley of the Thames, and it is probable that future research will greatly augment the mass of facts bearing on this subject. The ossiferous deposits in Val d'Arno may belong to an earlier period, but appear due to similar agencies.

PERMIAN STRATA IN THE VALE OF YORK.—If we regard the Vale of York as occupying the whole breadth of fifteen, twenty, or thirty miles from the slope of the great western hills to the foot of the eastern ranges of Oolite and Chalk, we shall find it everywhere largely occupied by the red and green marls, called in Germany Keuper, sandstones and conglomerates, generally red, but occasionally in their upper part white, called Bunter, which rest on the two-membered Magnesian Limestone, and are covered by the Lias. These taken in mass make about half a mile in thickness; but the Keuper and Bunter strata are not completely known.

*Section of Lias, Trias, and Permian Strata in the Vale of York.*

Oolitic series above.




Carboniferous series below.

In the Section just given, *c* marks the place of calcareous nodules used for cement; *j*, the place of the jet bands; *i*, ironstone; *l*, lias limestone; *w*, thin white triassic sandstone; *wh*, white solid sandstone, or 'waterstone'; *cg*, conglomerate of the Bunter sandstone.

The Permian strata, most completely exhibited about Knaresborough, Pontefract, and Doncaster, are somewhat interrupted in the country between Tanfield and Pierce Bridge, the lacunæ being due more to ancient surface-denudations than to original deficiencies of deposit.

In Durham the series is continued, without the upper member of the limestones being distinctly traceable; this also fails as we go southward toward Mansfield and Nottingham. The lowest stratum of yellow or purplish sandstones is variable and irregular everywhere north of Pontefract, where it is apparently, if not really, in conformity to the Coal-measures, which there show their highest parts. Here they somewhat resemble the lowest Permian sandstones of Manchester.

In Durham, the "marl-slate," whose thin laminæ are crowded with fishes, occurs in this part of the series, but is not yet recorded distinctly in Yorkshire, though some thin laminated beds with fossils, at Garforth, may be held to represent the deposit.

The Lower Limestone, specially called Magnesian or Dolomitic, is the most continuous member of the series, and locally fossiliferous, especially in some particular zones, as the lower part at Garforth, the middle part at Weldon. The composition of this rock is that of a double carbonate of lime and magnesia, when in its purest and most crystalline state. One hundred parts of such contain of carbonate of lime 54·3, and of carbonate of magnesia 45·7. This lime, obtained by burning, is exceptionally good for some of the uses of the plasterer and builder; if employed in agriculture, some caution is needed on account of its comparatively long conservation of causticity. The stone, when properly selected and dried before use, is excellent for building; but if these precautions be disregarded, it is often found subject to rapid decay. I have found well-cut stone which seemed good perish in fourteen years. Mansfield, Bolsover, Wandsworth, Broadsworth, Huddlestone, and Weldon are names famous for yielding large quantities of fine stone in large masses of excellent white, yellow, or reddish colour and durability. Its character is not so good in the northern part of its course, where, indeed, it is frequently full of geodic-spar cavities and pulverulent. Copper carbonate occurs in it at a few points, as Newton Kyme and Farnley, and oxide of iron with sulphate of baryta at Huddlestone. Among the

fossils are *Modiola acuminata, Mytilus squamosus, Axinus obscurus, Producta aculeata, Pleurotomaria, Nautilus.*

The Gypseous Marls are of the same tints and qualities as the Keuper above, and contain usually a proportion of gypsum, by which the spring-water which they yield is injuriously affected.

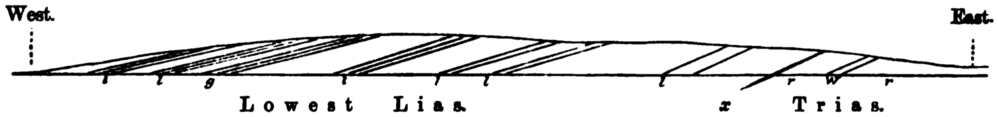
The Upper Limestone contains only a small quantity (usually under 5 per cent.) of magnesia, and makes a fine white lime, greatly employed in agriculture. A few shelly layers are seen in it near Ferrybridge; but, excepting *Modiola acuminata*, I have not positively identified any species. The stone is usually buff-coloured or of purplish hue, fine-grained, and formed in many thin layers separated by still thinner clays.

Red and pale laminated clays lie over this rock at Knottingley, and may be held to unite by mineral analogies the Permian and Triassic strata, however much they differ by fossil contents, in countries which are more favoured with these sure marks of the lapse of time and distinction of strata.

THE BUNTER SANDSTONE, regarded in a general manner, is of small importance at the surface in Durham and the northern part of Yorkshire, but occupies more and more extensive spaces as we proceed southward. It exists, however, on the Tees at Middleton-one-Row (where it was penetrated to the depth of 600 feet), largely about Ripon (where remarkable landfalls have occurred in it through the removal of parts of the rock by subterranean streams flowing toward the Yore), and about Boroughbridge, where white sandstone lies at the top. It is seen at Bilborough, and again in a loose and more pebbly state, forming hills, in the low country east of Sherburn, Womersley, and Doncaster. Hence in the southward direction it becomes more and more pebbly, and maintains this partially conglomerate character through the midland counties. This rock does not reach the Yorkshire coast.

The Keuper Marl, rarely exposed to any great thickness, is first seen in the low borders and the coast about Middlesborough, where it has been penetrated in an experiment for water, and found to contain rock-salt. In no excavation which I have seen of these marls in Yorkshire is there any trace of the fossiliferous sandstone which so has long a range in the vales of the Severn and the Avon.

LOWEST LIAS, INFRA-LIAS?, RHÆTIC?—I have had several opportunities of inspecting the line of railway from York to Malton, step by step; formerly the cuttings were clear between Barton Station and Malton, and I made a section on a large scale. The most remarkable part of the drawing represents the junction, which was well and completely seen, of the Keuper Marls and the lowest Lias on the western side of a broad anticlinal between Barton Station and Howsham. The subjoined is a copy.




*l, l.* Thin bands of limestone in thicker beds of lias shale. *g.* Beds with *Gryphæa incurva, Cardinia,* &c. *r.* Red marl. *w.* White band in the red marl.

The strata strike N. 70° E., and dip 45° to 15° northward.

The Keuper Marls were red, except one greenish-white band near the top.

The Liassic beds were all bluish or grey, and consisted of shales alternating with no less than eighteen thin calcareous bands; the whole series was about 100 feet thick, and occupied about 750 feet in length; it was poor in fossils, but towards the upper part *Gryphæa incurva, Cardinia,* and *Serpula* were noted in the limestone-beds, which were always only a few inches in thickness. Of these beds only two, and those partial, were noticed in the lowest part. It appeared to me at the time that here were to be seen, in one section, all that North Yorkshire had to show of the lowest Lias beds, including indistinct representatives of the Westbury beds, now called Rhætic.

Quite lately the beds of the lower liassic zones, connected with *Ammonites angulatus* and *A. planorbis*, have been examined at Cliff, near Market Weighton, by the Rev. J. F. Blake, and found richly fossiliferous*. On a late visit to this locality, I found these beds to consist of clays, with very thin limestones and some sandy layers, the lower zones having certainly the aspect of Rhætic strata. They appear to correspond with what is recorded above.

* See Geol. Journ. 1872, p. 132, for full lists of the fossils.

# CHAPTER III.

## THE MOORLAND DISTRICT.

THIS large tract of heathy hills, formed on the lower oolites and green woody valleys mostly excavated in the Lias, is remarkable for presenting, along its whole outline, a range of bold and steep escarpments. Its overhanging cliffs, which so strikingly characterize the coast between Scarborough and Redcar, are among the loftiest in Britain; and where it turns inland from Huntcliff, by Rosebury Topping, Burton Head, Dromanby Bank, and Osmotherly Moors, it maintains the same high and precipitous aspect, and looks over the plain of Cleveland and Mowbray, as the ranges of Cleeve and Broadway overlook the vales of Gloucestershire. This similarity of appearance is owing to analogy of geological structure. The wide vales of Gloucestershire are, like the Vale of Cleveland, based on Red Marl and Lias shale; and the oolitic rocks of Cleeve and Broadway are represented, though with great variations, by the rocks of the corresponding escarpments in Yorkshire.

Including that portion of the Vale of Cleveland which is based on the Lias formation, this division contains about 550 square miles. On the south it is bounded by the elevated edge of oolitic rocks which range, nearly in a straight line, from Scarborough Castle to Hambleton End (see the Map). It comprehends the whole drainage of the river Esk, and on the north of that river forms an imperfectly connected range of hills, from near Whitby to Rosebury Topping, with detached secondary elevations on the northern coast, at Rockcliff and Huntcliff, and the inland escarpment of Eston Nab. According to Col. Mudge, the heights on this range are as follows:—Rosebury Topping, 1022 feet; Eston Nab, 784 feet; Danby Beacon, 966 feet; Easington Heights, 681 feet. The Esk flows nearly along the line of a great dislocation, by which the strata on the north of the valley are much depressed. It is on the south of this

river that we find the most elevated and extensive moorlands. From the cliff at the High Peak, near Robin Hood's Bay (600 feet), a range rises and extends westward by Stow Brow (800 feet), Lilhoue Cross (1000 feet), Egton Moors and Loose Hoe (1404 feet), to Burton Head (1485 feet). This is supposed to be the highest point of land in the eastern part of the county; but the ridges are still very lofty which pass by Wainstones (about 1300 feet) and Carlton Bank, round the head of Scugdale, and by Osmotherly Moors, to sink beneath the highest point of the next range of hills, composed of the Oxford Oolites, at Hambleton End (1246 feet above the sea, according to Col. Mudge)*.

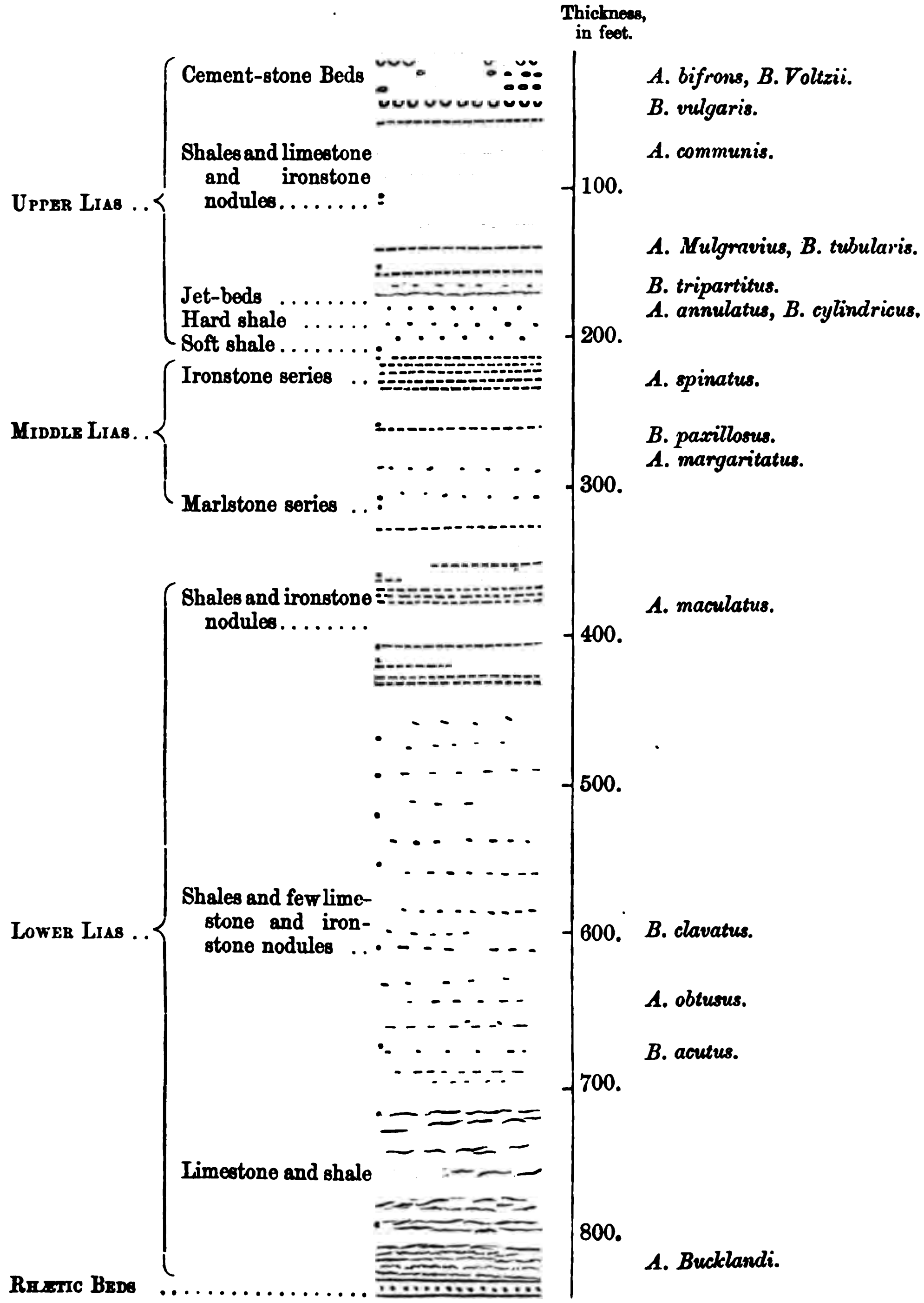
The principal valleys, properly called "dales," which open into the river Esk, or have independent courses to the Derwent, are mostly deep enough to penetrate the Lias to the Cleveland Ironstone series, though in none, excepting Eskdale in its lower part, is there any working of this valuable material. Bilsdale, Farndale, and Rosedale are conspicuous and picturesque examples of these dales, which were not without establishments whose ruins remain to attest the taste and magnificence of the monastic settlers in Yorkshire.

It will be useful to present here the general section of the Lias of Yorkshire, though the lower parts of it are only to be seen on the northern coast, and in the eastern part of the vale of York.

In this tabular view some of the more characteristic fossils are marked opposite their places in the successive strata. The Ammonites and Belemnites lie in pretty regular zones in all the liassic deposits of Yorkshire, nearly in the same order as they have been found by Dr. Wright and others in the south of England.

* In the progress of the National Survey many corrections have been made in the earlier determinations. It is thought proper to preserve these in the text, with the more numerous original barometrical measures, and to present a corrected list in the Appendix.

*Section of Lias in Yorkshire.*



THE LIAS FORMATION.—The Lias formation first appears on the sea-coast, under the High Peak, near Robin Hood's Bay, and continues along the shore, with only one exception west of Whitby, to Saltburn and Redcar—being very generally covered, in all the higher cliffs, by "dogger" and portions of the Carbonaceous formation. Its great thickness is apparent in the sides of Robin Hood's Bay, and in the precipices of Rockcliff. Inland, it follows the sinuosities of the moorlands above Guisborough, by Rosebury Topping, Burton Head, and Carlton Bank, towards Hambleton, and extends a considerable space into the low plains lying to the west of those hills. It is exposed by denudation along a great part of the valley of the Esk and in many of its tributary branches, as well as in the deep hollows of Bilsdale, Bransdale, Farndale, and Rosedale, and appears to be the general base of all these elevated moorlands. Its utmost thickness is not visible on the sea-coast, though in Rockcliff, and on the sides of Robin Hood's Bay, nearly 600 feet are exposed. At the head of Bilsdale the upper edge of the Lias is 800 feet above the plain below, and 1000 feet above the town of Stokesley, which is on the same formation. In Rosebury Topping the upper edge is 1000 feet above the lower beds of it at Redcar. Where the moorlands slope beneath the second hilly district, at Hambleton, the Lias descends and spreads in the low ground about Thirsk, Easingwold, and Sheriff-Hutton. It crosses the Derwent at Howsham, and proceeds by Leppington and Bugthorpe, till it comes to be almost concealed under the chalk hills at Garraby and Bishop Wilton. Its course, however, is still continued, in a narrow tract beneath the chalk, by Millington and Londesborough to Market Weighton; after which it turns out from the wolds, and proceeds by Northcliff and North Cave, to the Humber near Brough ferry. Beyond this river its range is uninterrupted through Lincolnshire and the midland counties, to Bath and Lyme-Regis.

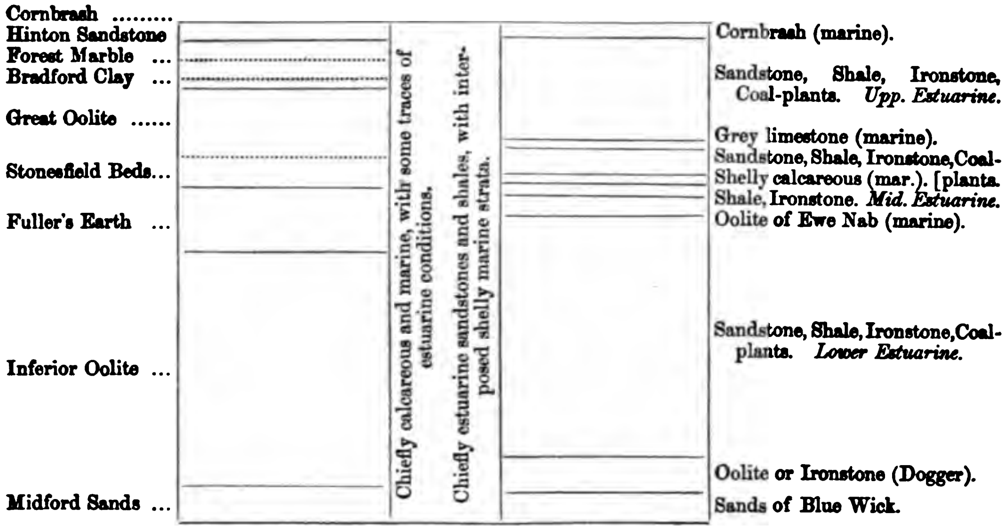
The upper edge of the Lias is so distinctly marked below the carbonaceous sandstones which cover it, that by means of many barometrical observations I am enabled to state, pretty distinctly, the average amount of its declination in several directions. It appears at a greater altitude along the breast of the hills south of Stokesley than in any other part

with which I am acquainted. Under Wainstones Cliff it was found to be nearly 1200 feet above the sea. At Brandsby, which is in a line due south, and distant nineteen miles, it is about 280 feet above the sea; the difference of level is equivalent to nearly 50 feet per mile. From the same point at Wainstones, the Lias sinks in an easterly direction to the level of the sea under the High Peak, at a distance of twenty-eight miles; this is at the rate of nearly 43 feet per mile. From the same point the dip to the top of the Lias on the south side of Whitby harbour, in a direction E. by N., is 55 feet per mile. The general declination of strata, in the district south of the Esk, is towards the S.E. On the north side of that river the upper plane of the Lias is nearly 1000 feet high in Rosebury Topping. From here to the Lyth alum-works, distant seventeen miles and a half, in a direction almost due east, the dip is 800 feet, or about 45 feet per mile; to Rockcliff, E.N.E., twelve miles, the dip is 46 feet per mile, to Eston Nab, N., four miles, 80 feet per mile. Hence it may be inferred that on the north side of the Esk river the strata generally dip to the N.E.

The above measures were taken in directions where the results are little affected by dislocations. But local variations of dip are very numerous. From Huntcliff and Rockcliff the strata sink both toward the east and the west; between Whitby and Bay Town they form a basin with meeting slopes; and in Robin Hood's Bay they turn up in what is called a saddle. The most remarkable of these dislocations are under the High Peak and west of Whitby. (Consult the section at all these points.) The three members of the Lias formation may be seen on the sea-coast in juxtaposition at Robin Hood's Bay, and in the high cliffs of Boulby and Rockcliff. The upper and lower shales are seldom so well exposed as to admit of being studied with advantage inland: but the middle group may be examined in Eston Nab, in Eskdale, along the front of the Cleveland Hills, in Bilsdale, and in the neighbourhood of Easingwold; and in all these places its characteristic position in the shale, and the abundance and peculiarity of its imbedded fossils, eminently distinguish it, and strongly remind the geologist of the "Marlstone" of Lincolnshire and Northamptonshire, to which it is certainly to be referred.

The rocks which compose the hills and cliffs of this moorland tract belong to the Lower or Bath Oolites, but present a very different aspect from that which they offer in the South of England, as the following comparative sections will show :—

Kelloway Rock above.



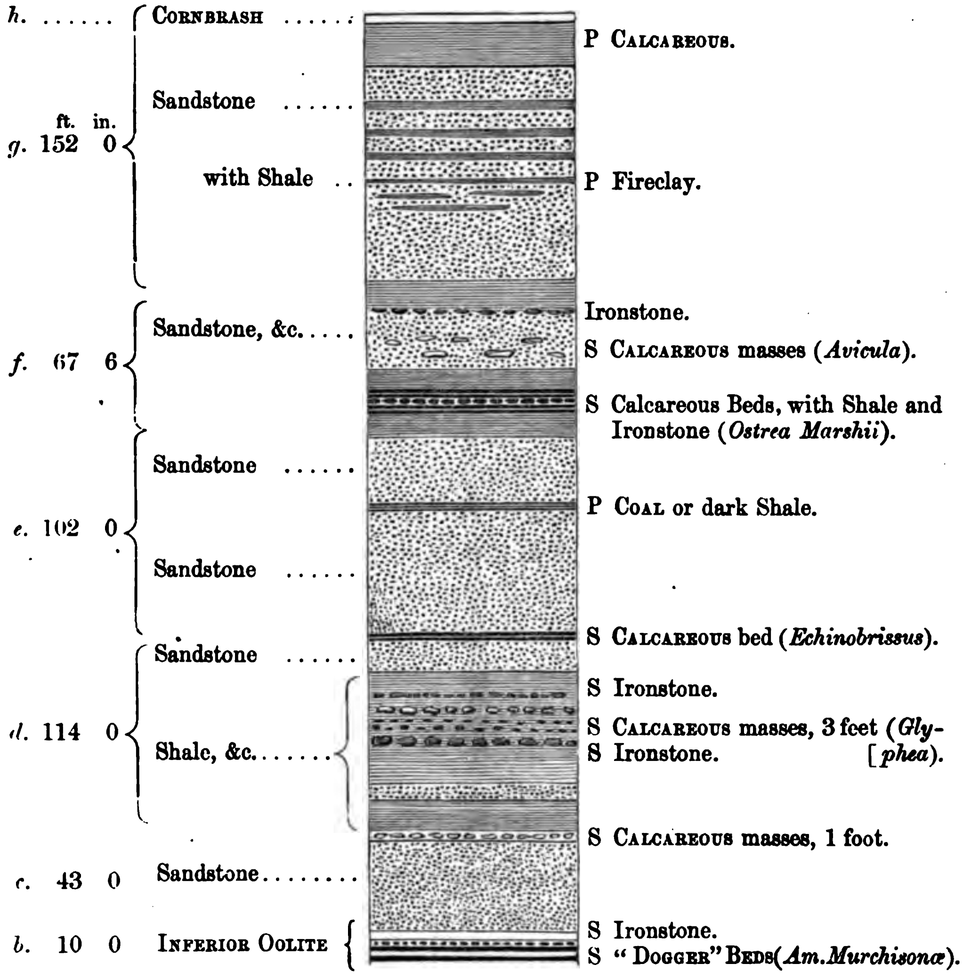

Lias Shale beneath.

The Cornbrash above and the Sands below occur and are sufficiently identified, by position in the strata and organic remains, in both districts; but the correspondence of the intermediate beds is not yet well made out. Judging from the proportional thicknesses and some other circumstances, the grey limestone of White Nab in the middle part of the Yorkshire section was referred by Smith to the Great Oolite; and this opinion should not be hastily abandoned, notwithstanding that some remarkable fossils in these rocks (*Ammonites Blagdeni, Belemnites giganteus*) seem to claim for it a collocation with the Inferior Oolite, to which the "Millepore-bed" of Ewe Nab and Gristhorp and the "Dogger" of the cliffs near Whitby were and may be boldly referred.

Combining modern views with Smith's dictum, we should have the three estuarine groups of the Yorkshire Oolite in the place of Forest marble, Fuller's earth, and some part of the Inferior Oolite. There is reason to expect that the Yorkshire series can be found represented in

Lincolnshire and Northamptonshire, but perhaps no great probabilty that any of these beds, excepting the uppermost and the lowest, can be exactly placed on coeval lines with the subdivisions of the almost wholly marine deposits of Bath.

The Oolite and other Limestones of Ewe Nab, White Nab, and Gristhorp will be specially considered when we come to describe the sections on the sea-coast. It will be useful here to present, in a diagram, the diversified series of beds observable in the Hambleton Hills, above Thirsk.



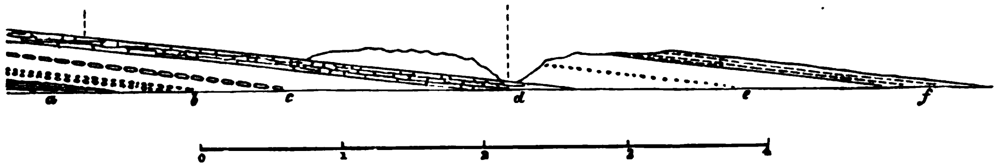
In this fine section, which measures 489 feet, we have, including the Cornbrash (here but indistinctly seen), seven bands of calcareous rock, all thin, and mostly nodular. Only the upper and lower can be confidently referred to corresponding terms in the Bath series. The infra-Oolitic sand of Midford and Frocester is not traceable near Thirsk. The lowest bed (truly Inferior Oolite) is rich enough in iron to be of considerable value for the furnace. The two calcareous beds next above are of the kind of rock here called "cement-stone." The letter S is placed opposite the zones where shells have been observed. These are all marine. P marks the occurrence of plants.

Above Brandsby and the neighbouring villages, the high ground affords a considerable variety of strata in this moorland series, but neither the highest nor the lowest. The following section is marked with letters to show the supposed agreement of the main divisions with those in the vicinity of Thirsk.

| | | ft. | in. | ft. | in. |
|---|---|---|---|---|---|
| *f.* | Sandy series, mostly yellowish, enclosing beds or broad flat nodules of hard somewhat sandy "glance" shelly limestone 2 to 5 feet in thickness, much valued for roads ("Road-stone") | | | 50 | 0 |
| | A parting of clay. | | | | |
| *e.* | Sand and sandstone with shells | | | 30 | 0 |
| *d.* Calcareous Series | Limestone, hard, somewhat sandy "glance" | 4 | 6 | 17 | 11 |
| | Clay, pale | 1 | 3 | | |
| | Ironstone | 0 | 2 | | |
| | Clay, pale | 3 | 0 | | |
| | Limestone, in solid beds 2 feet 6 each<br>Clay | 9 | 0 | | |
| *c.* | Shale, Carbonaceous grits, and coal | | | 50 | 0 |

In the vicinity of Castle Howard and Kirkham, especially along the railway about Crambe-Beck Station, we have a continuous section of the Bath Oolite series from the Lias upwards to the Kelloway rock. This favourable exposure was explored many times during 1851–57, and again in 1872, with the result expressed in the longitudinal section which follows, the letters having the same meaning as before.

*Section on the Railway near Castle-Howard Station.*



Taken in vertical order, we have:—

| | | ft. in. | ft. in. | ft. in. |
|---|---|---|---|---|
| *f.* Sandy and calcareous series, many conchifera, 20 feet. | Sands | 2 0 | | |
| | Shelly sandy "glance" nodules and beds | 6 0 | 20 0 | |
| | Sands, white above, yellow below | 10 0 | | |
| | Shelly sandy limestone | 2 0 | | 34 0 |
| | Clay, laminated<br>Yellow sandstone | | 10 0 | |
| | Shelly laminated sandstone | 2 0 | 4 0 | |
| | Shelly subcalcareous beds | 2 0 | | |
| | Clay parting. | | | |
| *e.* Sandstone, shale, ironstone, &c. | Sandstones, brown, yellow, thick and thin beds | | 30 0 | |
| | Clay and ironstone lumps | | 1 0 | 61 0 |
| | Sandstones | | 30 0 | |
| *d.* MILLEPORE OOLITE with many fossils | Oolite often large-grained | | 30 0 | |
| *c.* Sandstones, shales, &c. | Brown and variously coloured sandstones and shales | 30 0 | | |
| | Cement-stone and shales | 3 0 | 60 0 | |
| | Shale | 27 0 | | |
| *b.* Ironstone beds (Dogger) | Ironstone of Kirkham and Castle Howard | | 8 0 | |
| | Lias clays beneath. | | | |

Thus, in passing from the vicinity of Thirsk to the vale of the Derwent, the strata of the Bath Oolite series have lost two thirds of their total thickness, but the calcareous portions are on the whole augmented, their composition becomes more similar to the ordinary types of oolite, and their fossil contents are more numerous and more varied.

THE DOGGER SERIES (*b*), which immediately covers the Lias, is a group of rocks very variable in appearance and composition. Where fully developed, as on the sea-coast at Blue Wick, under the High Peak, it presents several layers of shells and pebbles, with a considerable thickness of subcalcareous irony sandstone, of which the lower grey part assimilates very decidedly to the Lias beneath, and corresponds to the Midford sands. In consequence of this assimilation, we may conclude* that both formations are here complete. In the sea-cliffs further west, about Whitby, Sandsend, Runswick, and the hill above Huntcliff, the Dogger series is not known to contain many shells; nor does it generally exhibit any such gradation in character to the Lias beneath. Some parts of the series, therefore, are in such cases wanting, the conditions of accumulation having been somewhat different. It is, however, usually more ferruginous, so as to be a valuable ore, though not so thick or of such uniformly good quality as the liassic ironstones below. Shells of the same kind as those which fill the Dogger at Blue Wick, are again found in it at the fine cascade, a few miles from Whitby, called Falling-force, in the upper part of Goadland Dale, and at Coldmoor and other places in the Cleveland Hills†. Commonly about Whitby and Robin Hood's Bay its lower layers contain nodular masses and fragments of ironstone, argillaceous limestone, red clay, porphyry, white felspar, quartz, and blende; but in the cliffs which range far to the west the Dogger is recognized only by its very irony composition and largely nodular structure. In some places it is even but little distinguishable from common sandstone, or is deficient altogether. Its utmost thickness, including sandy partings, is about 60 feet.

In consequence of its own characters, its position upon the Lias, and its evident assimilation to the Upper Lias shale, I think it may be concluded that the conchiferous Dogger beds at Blue Wick, and the ferruginous oolites of Rosedale, Thirsk, and Kirkham, are certainly the equivalent of the Northamptonshire iron ores, and of the lower part of the Inferior Oolite of Gloucestershire.

* See Professor Sedgwick's remarks on this subject, Ann. Phil., May 1826.

† The late Rev. L. V. Vernon afforded me valuable information while I was investigating the geology of the Cleveland Hills in 1826.

Coming southward from the cliffs near Whitby, we find this series of beds not so much replaced by as gradually changed into a ferruginous oolite, near Grosmont Bridge, and round the high edges of Rosedale and its branches, and a part of Farndale. In the continuation of this course westward it presents similar characters along the steep front of the Hambleton Hills, especially about Boltby, Sutton, and Feliskirk, near Thirsk. At all the places named it is or has been opened for ironstone, the richest of all the deposits being on the west side of Rosedale, where it ranges for miles. Here, within a limited space, it is a truly ferruginous oolite, containing magnetic sesquioxide of iron with strong polarity, and has yielded, for a thickness of ten or more yards, about 40 per cent of iron. Occasionally more calcareous, locally very ferruginous and very variable, the rock continues by Coxwold, Brandsby, Terrington, Whitwell, Kirkham, and Howsham, to pass under the unconformed edge of the chalk near Kirkby Underdale. It is feebly traced in the district of Cave, always calcareo-ferruginous and resting on Lias shale; and it is continued in Lincolnshire.

The SANDSTONES and SHALES (*c*), with fossil plants and coal, which succeed and cover the conchiferous series just described, rise from the sea a little north of Cloughton Wyke, and occupy the lower and middle parts of the cliff as far as the High Peak. They appear on all the higher parts of the coast, from Robin Hood's Bay to Huntcliff, and, thence retiring inland, in all the high Cleveland Hills before mentioned. The lowest part of this series of rocks usually contains a considerable portion of shale, and some thin layers of white and yellow sandstone, with fossil plants and irregular seams of bad coal. Occasionally this part swells out to a great thickness, and encloses two very distinct layers of fossil plants: those which lie nearest to the Dogger consist of cycadiform fronds and ferns of different kinds, and are imbedded in white carbonaceous sandstone and shale, or in ironstone (cliffs under Whitby Abbey). The upper layer consists of only one kind of equisetiform plants, standing vertically, as if in the attitude of growth, in a bed of sandstone, which rests on shale. A considerable thickness of sandstones and shales covers these plants at High Whitby and in Staintondale cliffs.

The complicated groups ($d, e, f$) of calcareous (marine) and arenaceous and shaly (estuarine) strata now to be noticed are of small agricultural value, but of great geological importance; for they afford a very ample suite of organic fossils, fully demonstrating their relation to the Oolitic formation of Lincoln and Bath, with which they are actually connected by intermediate points, though on a first view they appear very unlike.

MILLEPORE OOLITE.—The lowest group ($d$), the "Millepore rock," is seen in the extensive low-water scars between Gristhorp and Redcliff, and at the northern point of Cayton Bay. From this point it is below the level of the sea till we pass Cloughton Wyke, beyond which it rises along the high cliffs of Haiburn and Stainton-dale to near the Peak house. Hence it recedes inland, and, after passing by an obscure course across the moors, reaches Hood Hill, Coxwold, and Owlston. It now becomes more decidedly oolitic, ranges by Brandsby, Terrington, and Crambe to the quarries about Westow, and is continued more obscurely between Leppington and Acklam, to pass under the chalk hills. This oolite reappears from beneath the wolds at Sancton, and ranges by Newbald, Everthorpe, Ellerker, and Elloughton to the Humber, near Brough ferry. The lower part of the Lincolnshire Oolite, beyond this river, is a continuation of the same rocks.

The NON-CALCAREOUS group ($e$), consisting near Thirsk for the most part of sandstones, contains, however, one band of coal or dark shale, like those which at Gristhorp yield so many plants.

The CALCAREOUS group ($f$) is the "grey limestone" series of the shore south of Scarborough, especially at White Nab. On the sea-coast, and in the eastern moorlands, these calcareous strata are much debased by admixture of sand, argillaceous matter, and ironstone, so as to be very indifferent limestone, and very unlike the usual appearance of Oolite. In the western part of the same district their aspect changes; the upper fissile portion, at Brandsby and Terrington, appears on a first view to agree remarkably in structure, composition, and organic remains with

the slaty stones of Wittering Heath and Collyweston in Northamptonshire, and in a less degree with those of Stonesfield near Oxford. Mr. Lonsdale's researches have proved the Stonesfield rock to belong to the lower portion of the Bath Oolite. The Collyweston beds are believed to be of earlier date, and to lie below the excellent freestone of Ketton, which is a part of the Inferior Oolite. This slaty stone hardly occurs in a satisfactory manner on the sea-coast.

THE SANDSTONES AND SHALES (*g*) next to be noticed, which rest upon the grey limestone, have a general resemblance to those which cover the Dogger. The lower part consists chiefly of thick irregular strata of sandstone, with nodules of ironstone and layers of shale, containing local and scattered deposits of fossil plants. Above is a thick deposit of dark and light-coloured shale, with alternations of thin sandstones, and a few interesting plants (leaves of Zamiaceæ and Ferns).

The plants which lie in the shale and ironstone belong to the same tribes of Zamiaceæ, ferns, and lycopodiiform plants as those which occur in the Lower Carbonaceous sandstones; but the species are frequently, if not generally, distinct. The sandstone is often filled with fragments of carbonized wood, like so many pebbles; and occasionally it contains large carbonized branches. Its surfaces are generally blackened by particles of the same substance. This series may be observed upon the coast from Gristhorp Bay to near Scarborough, and from that town northward to Cloughton Wyke; and its lower sandstones appear along the top of some of the high cliffs between Haiburn Wyke and the Peak. Its course inland is on the north side of the tabular hills which range from Scarborough to Hambleton, but is not easily defined across so wild a surface of heath and bog. It is probably thickest, and certainly is best known, in the vicinity of Scarborough.

THE CALCAREOUS BED (*h*) which is found at the top of this Carbonaceous formation has a considerable resemblance to the calcareous layers (*f*) which have been already described; but its position under the Kelloway rock, and the general character of its organic fossils, justify Smith's opinion, that it is referable to the "Cornbrash" limestone of the southern counties.

It is a thin, fissile, partially oolitic stone, remarkably filled with *Terebratulæ*, *Trigoniæ*, Unioniform shells, and small *Echinobrissi*. Gristhorp Bay and Redcliff, and the vicinity of Scarborough, are the only points where I have seen it distinctly exposed on the coast; and great difficulties must always attend the efforts to trace so thin a rock across the interior of the country. I have examined it in Newtondale, where it is much thicker than on the coast; it is hardly distinct on the western side of the moorlands, about Thirsk; and in the vicinity of Kirkham, Westow, and Cave, and in the northernmost part of Lincolnshire, its presence is not yet proved.

In the south of England, from Cheltenham to Yeovil, the Lower Oolites are almost wholly composed of marine sediments, the Forest-Marble series showing, however, by frequent examples of drifted wood, and repeated admixtures of shell bands and clay partings, some indication of the influence of inflowing river-currents. In the Yorkshire series, on the contrary, the sediments are principally such as might be furnished by rivers varying in force and subject to intervals of feebler action. Thus we have thick and thin beds of sandstone, with sandy shales, and fragments of stems and branches and leaves of plants—plants of dry land, as the Zamiaceæ, of the marshes, as *Equisetites*, but most rarely of the sea, as a few fucoids. Even beds of such plants occur and make thin, poor coal-seams; and many bands and nodules of ironstone are noticed; while at several intervals calcareous beds appear and exhibit a considerable series of marine exuviæ.

If we were to put out of consideration the shelly beds of limestone, we should find in these carbonaceous rocks much resemblance to that more ancient deposit of coal and sandstone and shale which has been expressly called the "Coal formation." But we are furnished with the most satisfactory means of discrimination in the plants which accompany the coal; for though perhaps one hundred species of fossil plants have been discovered in the West-Riding coal-field, and not less than fifty in the sandstones and shales of the north-eastern coast, it is not too bold an assertion that no one species has yet been found which is common to both situations.

This tract may be regarded as an oolitic "Coal-field" accumulated with some disturbance, or a "Wealden" which was produced by currents flowing into the oolitic sea, from lands which had been previously elevated on the north and west—palæozoic lands, part of the Penine and other ancient ranges, which have formed, it is probable, the original shore of the Mesozoic deposits of every age till the close of the Cretaceous period.

The whole mass of the arenaceous and shaly interpolated sediments becomes thinner towards the south, does not cross the Humber, and is indeed almost extinct on the parallel of Malton; while, on the other hand, in the same direction the calcareous masses grow on the whole thicker and collect into more distinct groups, from which the transition is easy to the more normal series of oolitic beds in Lincolnshire. In that district the Fuller's Earth has not been traced; and thus only one thick series of limestone rocks is found to compose the "Cliff" range, with brown, grey, and white sands and sandstone and ironstone below. These sands open out in Northamptonshire and become in part calcareous, showing at Collyweston thin beds like those of Brandsby in Yorkshire, richly stored with shells, and in some parts Ironstone of great value. In some places, as near Stamford, Northampton, and Weedon Beck, the frequent alternations of calcareous, ferruginous, and arenaceous layers, and the occurrence of fragments of land-plants, give them somewhat of an estuarine character; and the same conclusion may be adopted for the Forest-marble series; so that there, as in Yorkshire, we have traces of the proximity of land and the interference of river-floods. By combining all these indications, we have in the Oolitic period of England a direct, if not complete, history of the sea and its shores, and a probable view of the condition of the adjacent lands.

One of the remarkable features in this country is the frequency of Ironstone bands, mostly composed of nodules or aggregated masses, and generally of good quality, but too thin for working, in presence of the now famous beds of Cleveland, which lie in the Lias above the Marlstone. The exception is the lowest bed of all, the "Dogger" (a name borrowed from the alum-works), which is a true representative of the Inferior Oolite, with the granules wholly or partially converted to carbonate of iron. This has been found in several tracts thick enough and rich enough to be employed in the furnaces, as in Rosedale, about Thirsk, and about Kirkham.

The economical questions connected with the Ironstones will be referred to again.

Another striking peculiarity of the district is the great "dyke" of basaltic rock, which literally cuts through the whole county, following a nearly vertical fissure, from Teesdale across the Coal-field of Durham, the Red Marls of Stokesley, the Lias of Eskdale, and the sandstones and limestones of the moors, on a line by Silhoue Cross toward the Peak, which, however, it does not reach, though we may, perhaps, regard the great fault in that high cliff as formed on a continuation of the fissure, in which the Basalt was consolidated from a state of fusion. This dyke must be the subject of further consideration.

The surface of the higher parts of the district now under review is almost uniformly heathy, with narrow and interrupted patches of greener herbage, where the limestone bands obscurely appear, or small springs encourage the growth of moisture-loving plants. The valleys, for the most part deeply sunk into the Lias, as Eskdale, Bilsdale, Bransdale, Farndale, and Rosedale, or winding among cliffs of sandstone and limestone, as Newtondale and Harwooddale, are picturesque with girdles of rock, or beautiful with green slopes, sheltered homesteads and woodland waterfalls. The hills are conspicuously marked by tumuli of Anglian and British races, traces of Roman roads and camps, and pit dwellings of earlier people.

Possibly these broad moors, now almost abandoned to the grouse, were once in a different physical condition, and yielded more sustenance to flocks and herds; in some places the marks of ancient industry seem traceable; and if lime were abundantly employed on well-selected parts, after efficient drainage, we might see nutritious herbage spring up in abundance where, though unaided, white clover now maintains a feeble struggle for existence with the overmastering heath, and with fair encouragement even wins a partial victory.

# CHAPTER IV.

## THE TABULAR OOLITIC HILLS.

THESE hills meet the sea-coast between Filey and Scarborough on the east. They rise toward the north from under the Vale of Pickering, and terminate in a remarkable line of escarpments at Silpho Brow, Blakehoe Topping, Saltergate, Lastingham, Easterside, and Black Hambleton. From the Vale of Pickering the ascent to them is long and gradual, but from the northern moors it is very short and abrupt. The altitude of the hills increases westward. Thus Gristhorp cliffs are about 270 feet high, Oliver's Mount 490 feet, the heights above Troutbeck 650 feet, above Rievaulx Abbey 800 feet, and at Hambleton 1246 feet. Even at considerable distances, the plane summits and abrupt terminations of these oolitic hills are very remarkable.

From Hambleton the range proceeds southward by Wass bank, 900 feet, and eastward by Ampleforth and Oswaldkirk bank, 330 feet, to Stonegrave, beyond which place it sinks beneath the Vale of Pickering. A branch of this range, separated from Oswaldkirk bank by the valley of Gilling, extends in a south-easterly direction to Malton, where it crosses the Derwent, and, after rising into the high grounds of Langton wolds, turns again to the south, and passes under the chalk hills at Acklam. Some of the strata which belong to this group of rocks reappear from below the Chalk in the neighbourhood of South Cave, and are continued in Lincolnshire. The surface occupied by this district is about 190 square miles: it includes the following strata:—

*Section of the Middle or Oxford Oolite Series in Yorkshire.*

Kimmeridge Clay above.

| | Utmost thickness in feet. | Fossils. |
|---|---|---|
| Upper Calc. Grit | 60. | *Belemnites abbreviatus.* |
| Coralline Oolite | 60. | *Ammonites vertebralis.* |
| Lower Calc. Grit | 80. | *Cidaris florigemma.* |
| Oxford Clay | 150. | *Belemnites hastatus.* |
| Kelloway Rock | 90. | *Ammonites athleta.* |
| Clay | 5. | *Glyphea Stricklandi.* |

Cornbrash Rock below.

Of the strata here enumerated, possibly all may be equally extensive; but some are more easily traced than others. The Kelloway rock shows itself on the coast at Gristhorp and Scarborough, and at many points inland along the northern escarpment of the tabular hills; it sweeps round the western slopes of these hills, is traceable near Gilling and Castle Howard, and reappears in the neighbourhood of Cave. Everywhere characteristic fossils accompany it, and establish the agreement between this rock and that so named in Wiltshire, which had been already inferred from geological position. The argillaceous stratum which separates the Kelloway rock from the lower calcareous grit represents in Yorkshire the clunch clay, or Oxford Clay, of the southern counties. It continues along the breast of the great escarpment of the tabular hills from Scarborough towards Hambleton and Wass bank, and is less distinctly traceable where the same range turns eastward, by Ampleforth and Castle Howard; it has been penetrated to some depth near Malton, but has not yet been found about Cave. The lower calcareous grit and coralline oolite are extremely well connected from Scarborough round the Vale of Pickering to Acklam, but they have not been seen further south. The calcareous rocks which range close under the wolds of Lincolnshire do not belong to this formation, as many years since, with Mr. J. E. Lee, I had the means of ascertaining. They rest upon Kimmeridge Clay, and have been referred by Mr. Judd to the Neocomian series. The upper calcareous grit covers the coralline oolite at Stonegrave, Oswaldkirk, Ampleforth, and Wass bank, and, in lower ground, at Helmsley, Kirkdale, Pickering, and

Sinnington*. It also occurs, as Dr. Smith informed me, in the same manner on Silpho Brow, near Scarborough. At Kilburn, near Coxwold, is a great exhibition supposed to be of this rock, thrown in by a long line of fault †.

That all the strata of the tabular hills should be included in one "formation," appears to me satisfactorily demonstrated by the gradations they present from one to another. Thus the Kelloway rock changes into the Oxford Clay, which is still more evidently blended with the lower part of the calcareous grit. The calcareous grit and coralline oolite above are so harmonized at their junction, that it is not easy to mark the exact line; and the similarity of character between the upper and lower beds of calcareous grit completes the evidence which warrants the combination of all these strata into one natural group.

Whoever compares this series of strata with the coralline Oolite formation in Berkshire and Wiltshire, will find them extremely similar in the mode of arrangement, in mineralogical composition, and organic contents. The features which they impart to the country are much alike in both districts; and the whole evidence in favour of their affinity is complete and satisfactory. Yet the two districts lie wide asunder, and in all the intermediate tract a great portion of the series is unknown. From Acklam to the neighbourhood of Cambridge, no coralline oolite or calcareous grit appears at the surface; the Oxford Clay has, on the contrary, a large breadth. The Kelloway rock has not yet been described between Huntingdonshire and the Humber. The absence of the rocks is equalled by that of the characteristic fossils, those useful and often necessary guides to determine the affinities of detached portions of the strata.

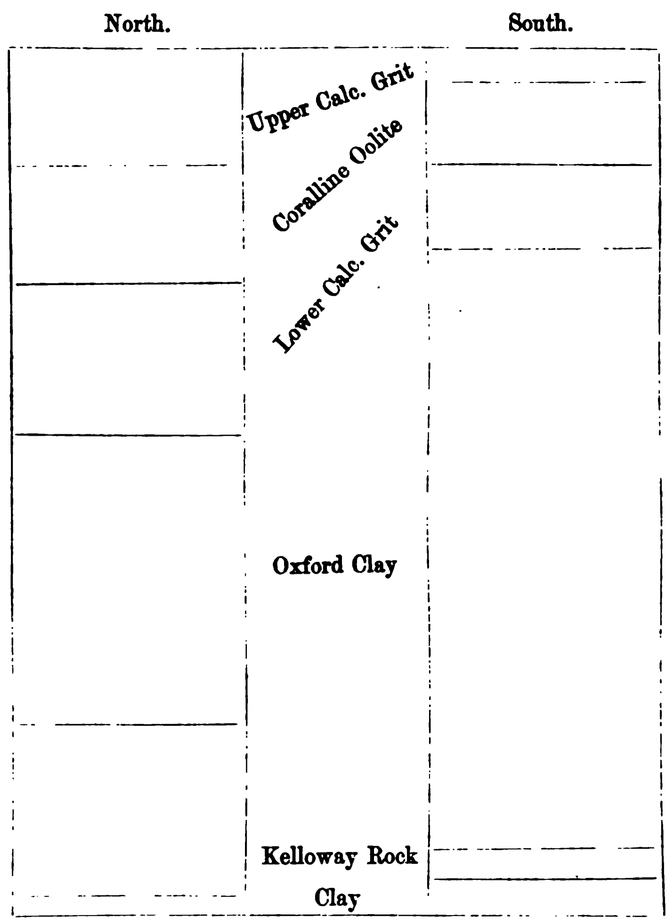
But where the rocks reappear, as at Upware, between Cambridge and Ely, many of the organic forms usually associated with them come again to view. In the country near Oxford the Kelloway rock is hardly traceable; but in the district near Cambridge, Mr. Seeley finds several such

* See Philosophical Magazine and Annals of Philosophy, April 1828.

† In examining this locality I had the advantage of being accompanied by Mr. C. Strickland about twenty years since.

strata associated with the Oxford Clay, and containing considerable suites of fossils.

On comparing the Yorkshire strata of this group with those of the South of England, we may remark, along with a striking general conformity, some differences worthy of notice. The sections which follow represent the proportions occupied by the several members of the formation, in the north and in the south respectively.




In a general view the arenaceous elements predominate in the north, the argillaceous parts are thickest in the south. They produce also more decidedly strong clay land. The oolitic portion preserves on the whole a more uniform thickness; but, being an aggregate of invertebral structures

and sediments derived from them, it is liable to much local diversity, remarkable reductions of thickness, and change of aspect. Some portions are a kind of coral reef, as at Great Ayton near Scarborough, Heddington near Oxford, and Calne in Wiltshire; in which, however, horizontal drifting of shells and displacement of coral masses may be observed; so that it is rather with a part of the shelly and coralline aggregates of Bermuda, and the sinking low islands of the Pacific, than with the uprising reefs of madreporic growth that the comparison should be made.

Oolitic structure is manifest in some parts of the Kelloway rock on the Scarborough coast, and in the valley of the Derwent. In descending the cliff at Gristhorp, we find a large-grained calcareous oolite in small quantity at the top of the Kelloway sandstones, with few fossils in the general mass; at Hackness, in a thickness of 90 feet, some parts are richly fossiliferous; on the front of the Hambleton hills, above Thirsk, there appears to be a division of the rock into two thick members, with a portion of Oxford Clay between them.

There is a band of clay below the Kelloway rock on the Yorkshire coast, which appears fairly referable to Oxford Clay, and is somewhat remarkable for containing *Glyphea Stricklandi*. Thus, in a complete view of this system in Yorkshire we must admit:—

Upper Oxford Clay.
Upper Kelloway rock.
Middle Oxford Clay (occasional).
Lower Kelloway rock.
Lower Oxford Clay.

And it appears likely that this way of considering the series will be found useful in other districts. Near Oxford three divisions in the Oxford Clay appear marked by the fossils, and especially the *Ammonites*, though Kelloway rock is not as yet distinctly proved there *.

The physical geography of the district of "Tabular Hills" offers a few subjects of interest. First, we remark the many narrow valleys which cut through the northern escarpment, and bring swift streams from the moorland sources.

The dales of Hackness, converging to the Forge valley, may be taken

* Geology of Oxford and the Valley of the Thames, p. 298.

as a favourable example of picturesque windings between woody slopes and conspicuous hills. Some of these dales are very short, and have their origin within the escarpment-edge, as if the strong springs to which they usually give passage might fairly be regarded as the local successors of excavators of the valleys in which they run. Others are rocky channels ploughed some hundreds of feet deep, through the sloping strata from the sandstones and shales below to the calcareous rocks above. Such are the principal dales of the Derwent, Newtondale, the lower parts of Rosedale, Farndale, Riccaldale, and Bilsdale.

In several of these valleys the stream loses water, or wholly disappears, when it arrives at the calcareous strata: in approaching the Vale of Pickering, it sinks into the open jointed rocks and fills the subterranean reservoir—the watery currents breaking out again further down the valley, considerably charged with carbonate of lime obtained by solution of the rocks in its underground channels. This is probably the very ancient origin of the caverns which have been examined at Kirkdale and in the vicinity of that famous "ossuary;" for these may well be supposed to have admitted at some former period, directly or collaterally, currents of water charged with carbonic acid.

The same general chemical agency may be appealed to for explaining in some cases the entire removal of carbonate of lime from the so-called "calcareous grit" rocks. These are found in many situations, where covered by upper strata and not much exposed to downward passing water, to be really very calcareous; but on open hill surfaces, and in other situations much exposed to atmospheric action, the shells are removed, and hardly a trace of lime can be detected in the sandy residual rock. Another thing observed in these grits, which perhaps may receive explanation from similar operations, is the occurrence of large spheroidal concretions, harder and more calcareous than the surrounding rock, which lie in one or more layers, parallel to the general stratification, below the covering oolite. It appears as if by dissolution of oolite above, calcareous matter were carried down into the strata below, and there collected round Ammonites or other organic forms—much as nodules have been formed round the Ammonites of the Upper Lias, and round the leaves of *Pecopteris* in the shales of the coal districts.

# CHAPTER V.

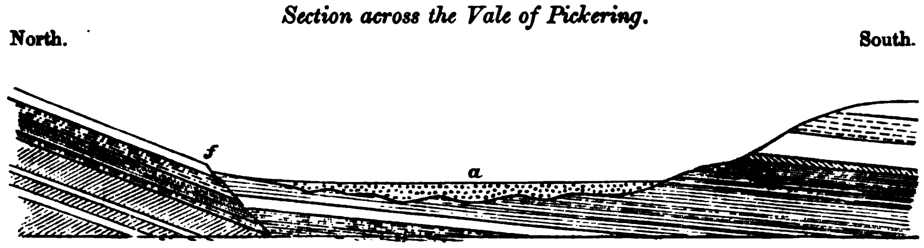
## THE VALE OF PICKERING.

THIS valley, or rather wide level, containing nearly 160 square miles of surface, lies between the parallel ranges of chalk and oolite. Its eastern portion, contracted by the nearer approach of these high ridges, is prolonged to the edge of the sea-cliffs about Filey; on the west its waters pass, by a narrow valley of denudation, through the oolitic hills which extend from Castle Howard to Malton and Langton Wold. Were this narrow passage closed, a large portion of the Vale of Pickering would become a lake, discharging itself into the sea near Filey, through cliffs about 70 feet high. Professor Buckland, in his admirable work, the 'Reliquiæ Diluvianæ,' seems to admit the probability of the Vale of Pickering having been an antediluvian lake, which was drained when the present outlet at Malton was effected.

The idea of its having been a lake naturally offers itself to every one who considers its wide level surface, and remarks the multitude of streams which run into it and pass out by the single channel of the Derwent. The *present* appearances of the vale can only be employed to support opinions as to its condition in late Pleistocene ages. The Vale of Pickering has a partial surface of alluvial sediment, and a general covering of diluvial clay and pebbles, upon substrata of blue clay. How vast a load of diluvium lies on the regular strata in particular situations, is known to those who have inspected the cliffs between Speeton and Filey; and similar accumulations prevent it from appearing in all the central part of the vale. The present flat appearance of this great hollow is due to alluvial agencies; but there are phenomena along its borders which afford some clue to its condition in earlier, probably even preglacial

times. First, we remark on the southern border the long escarpment of the Chalk wold resting on the upper blue clay of the vale, and presenting the aspect of a long-since-deserted sea-cliff—the softened continuation of the storm-beaten precipices of Flamborough Head. The softening of the wold hills and the ever rugged, fissured, and broken cliff, with its separated islands of chalk and flint, tell the same tale of the transforming influence of long-elapsed time. The present smooth aspect of the wold, due to gradual subaërial waste, disguises the effect of earlier sea-waves, acting with more powerful water-batteries. Could we displace the boulder-clays and let in the sea, no long period (speaking after the manner of geologists) would elapse before mightier cliffs than those of Dover or Beachy Head would hang over deeper waters, and be washed by heavy tides from Speeton Cliff to Settrington Wold.

*Section across the Vale of Pickering.*




*a.* Alluvial and diluvial deposits. *f.* Supposed fault.

Turning to the north we see the oolitic hills rising from the vale, with slopes corresponding in a general way to the dip of the strata, but yet often marked by steep descents toward the level ground and truncations of the rocks, which are very unusual on the dip side of gently inclined limestones. This front of the hills has been wasted by "denudation," to a considerable depth below the level of the vale, and in some parts (Ebberston, Pickering) suggests the idea of a fault-line from east to west (see diagram above). These appearances agree well with the supposition of a great sea-loch, into which the rivers entered from the north by channels usually turning eastward, as still happens to the branches of the Rye, and did probably happen in earlier times to the Derwent, one of whose sources is within a short distance of Filey.

To acquire right views of the early condition of the Vale of Pickering

may help us to understand what questions must be examined if we wish to determine the circumstances under which Kirkdale Cave was tenanted by its ferine population. Obviously the occupation was long enough to encumber the floor for 230 yards with the bony reliquiæ of many generations of hyænas and oxen; during this occupation the cave must have admitted no full flow of water, though formerly it had been traversed by rain or river-currents. It is equally clear that afterwards mud, arriving through joints of the rock, or poured in at the opening, was spread over these reliquiæ; and later still stalagmite, dropping from the roof, was deposited upon the mud and bones. Finally the mouth of the cave was blocked up by earthy masses and rocky fragments which descended from the hill above. Nothing in this summary of operations appears to require the agency of the sea, or indicate specially its proximity—though, if the valley were again filled with water, Kirkdale Cave might be likened to Bacon Hole near Swansea, and to the caverns in the cliffs of Palermo. But, on the other hand, admitting all the phenomena above stated to be connected with subaërial conditions, there still remain the questions (applicable to many such caverns), What caused the disuse of the cavern? Was it occupied in preglacial times, and closed by floods of the glacial age? Was a change of climate the cause of desertion or the agency of extinction?

Toward examining these questions something further is needed; a catalogue of the animals entombed in the cavern must be prepared and discussed; and that must be deferred to a future page. But it is worth remarking that Kirkdale Cave contained no traces of human works or instruments of any kind or any age, nor any evidence of more than one period of occupation by predaceous beasts, who derived some of their food from creatures living on the margin of a lake or among the reeds of a marsh, like some which occur in Central Africa, Southern Australia, or South-Eastern India.

It is the Kimmeridge Clay which forms the series of the greater part of the Vale of Pickering, as may be partly seen, but certainly inferred, from observations in the cliffs near Filey and on the shore at Speeton. But an upper belt of blue clay shows itself beneath the Chalk wolds at

Speeton and Knapton, and at each place produces fossils, some of which much resemble those of the "Gault" of Kent and Sussex. The lower blue clay appears along the north side of the Vale of Pickering about Kirby-Moorside and Helmsley, as well as at Settrington and North Grimston, near Malton, and at Elloughton, near Cave; and at several of these points it yields the *Ostrea deltoidea*, which is one of the most characteristic shells of the Kimmeridge Clay. Near Helmsley it admits in the lowest part some ferruginous sandy beds, and in the Speeton cliffs appears to be followed by a representative of the Portland sands*. The curious phenomena which accompany the southern edge of the the Vale of Pickering when it comes against the Chalk range at Speeton, will be noticed when the coast sections come under consideration.

* Both in respect of the Speeton clay proper, and the subjacent strata, geologists are indebted to Mr. Judd, whose reexamination of the Lincolnshire sections, near Caistor, has completed an investigation begun many years since by Mr. J. E. Lee, the late Mr. W. H. Dikes, and myself. By Mr. Judd's researches the relation of these strata to the Speeton clay and the Neocomian rocks of the continent has been made clear.

# CHAPTER VI.

## THE CHALK WOLDS.

THE Wolds of Yorkshire form one of the most remarkable features in this county. High and bare of trees, yet not dreary or sterile, they are furrowed as all other chalk-hills, by smooth, winding, ramified valleys, without any channel for a stream. Where several of these valleys meet, they produce a very pleasing combination of salient and retiring slopes, which resemble, on a grand scale, the petty concavities and projections in the actual channel of a river. No doubt these valleys were excavated by water, but not merely by the action of rains, or springs, or rivulets. Atmospheric influences have certainly moulded the surface to its present aspect; but something must be allowed for oceanic fluctuations in ancient times; for these have left unequivocal traces of mechanical energy exerted over all the region.

From the Humber, at Hessle, the high wolds range in a north-western direction to Riplingham Clump and Hunsley Beacon, 531 feet high, and, passing above Market-Weighton, reach their greatest elevation at Wilton Beacon, above Garraby, 805 feet above the sea. Hence their edge continues by Wharram and Settrington, and, turning to the east, skirts the Vale of Pickering, and fronts the sea in a long range of lofty cliffs from Speeton to Flamborough Head. From this elevated line the surface slopes eastward to Cottingham, Beverley, and Driffield, and southward to Burton-Agnes and Bridlington; and at all these places the chalk sinks below the wide diluvial and alluvial plains of Holderness. The extent of surface occupied by the Chalk formation of the Wolds is about 376 square miles, and the thickness of the stratum not less than 600 feet. Throughout its whole course the mineral characters are much alike, and its fossil remains nearly identical; yet, as the beds are more completely exposed

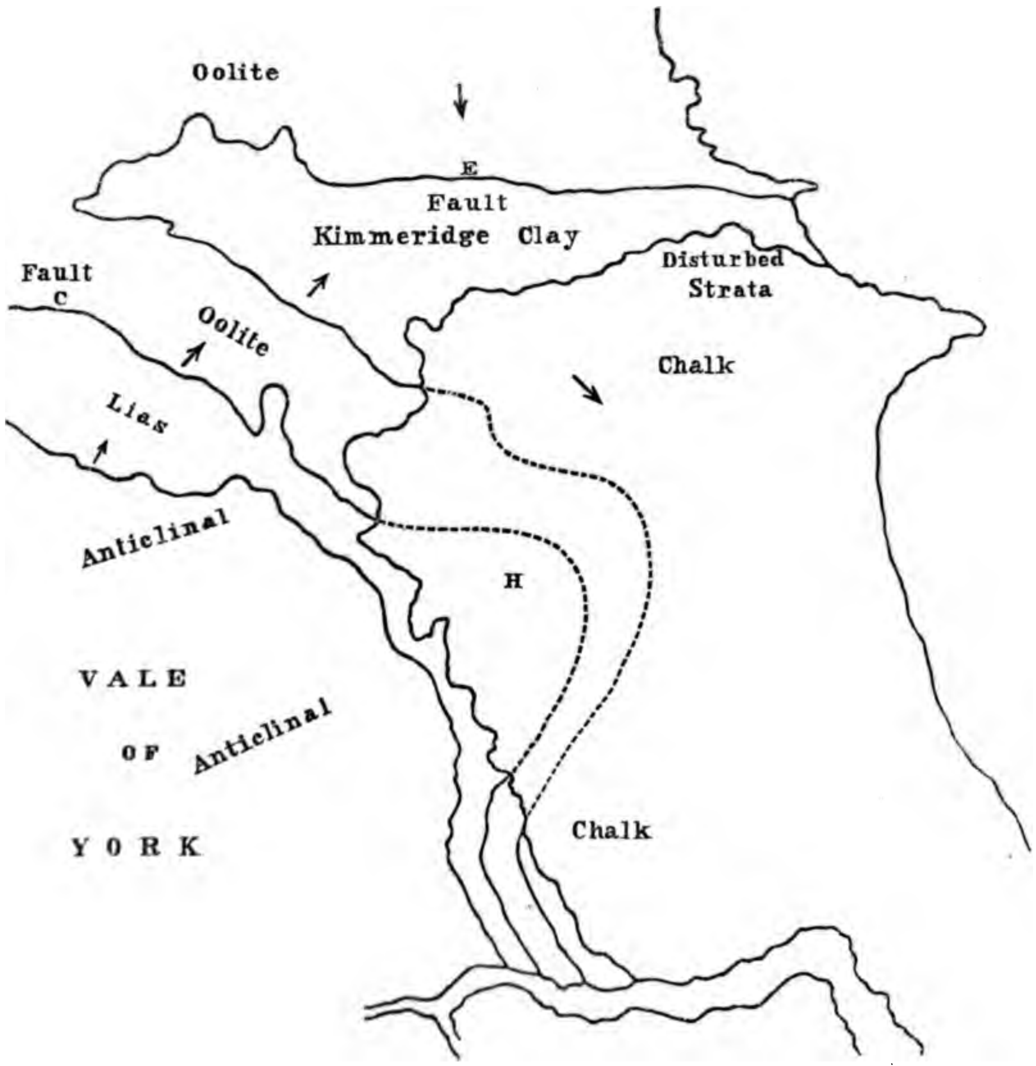
on the sea-coast, it is from Bridlington and Flamborough that most fossils are procured. The rock is generally much harder than in the southern counties; and the layers of flint are more diffused through its substance. On the western slopes of the wolds, as about Bishop-Wilton and Brantingham, the lower portion of the Chalk is softer than the upper part, and apparently more argillaceous; it seems to correspond with the Chalk-marl of Oxfordshire; but no fossils have been collected from it. At the bottom are red layers containing small Belemnites (*B. Listeri*) and Terebratulæ, which do not occur above. The blue clay of Speeton ends abruptly under the Chalk, without any traces of gradual change.

In wells and pits sunk on the wolds the Chalk has been several times perforated, and found to rest on Kimmeridge Clay near Sherburn, and on Lias, containing characteristic fossils (of which specimens have been presented to the Yorkshire Philosophical Society by the Rev. T. Rankin), at Huggate. The latter fact is highly important, as it shows to what an extent the unconformed arrangement prevails under the central part of the wolds.

The unconformity of the Chalk to all the strata beneath it is a striking feature of the geology of Yorkshire. The diagram on p. 52 shows how the map of the strata is affected by this circumstance, the nearly straight outline of the chalk cutting across the reentering curves of the Oolite and Lias. These curves depend upon one main, very broad, and gentle anticlinal elevation, from which the strata of earlier date than the Chalk decline towards the north and towards the south. The summit of this anticlinal was truncated, and large denudation of the Lias and Oolite occasioned; and then broad strata of Chalk were laid over the whole waterworn surface, so as to cover a large part of the Lias and conceal all the Oolites for a distance of from twelve to twenty miles. The dotted lines represent the course of these strata under the Chalk, with some approach to accuracy, since the Lias (to speak exactly it is the Upper Lias) has been found immediately under the Chalk, in a deep well at Huggate (marked H).

The anticlinal to which this remarkable arrangement is mainly due is

the southern one marked on the Map; some effect must also be allowed to the northern one, which has been already mentioned in describing the Lowest Lias of the Vale of York, p. 23. And, in relation to the earth-




movements which have affected the physical aspect of the region, the faults further north, which pass by Coxwold (marked C) and by Ebberston (marked E), may be considered of similar geological date. It is not proved as a fact, but may be readily accepted as a probable inference,

that the Chalk once extended much further to the west and to the north than its present escarpment-line, in this respect agreeing with what is inferred as to the Midland districts, and observed on the Dorsetshire coast. A great system of upward earth-movement and surface-waste succeeded the deposition of the great series of Oolites in England and many parts of Europe, and was followed by a large depression, deep water, accumulations of cretaceous mud, with a prevalence of foraminifera and Echinodermata, and abundance of sponge-growth in silicated waters, which characterized the Cretaceous æra, and may still be found in some degree to prevail in the deep basins of the Atlantic and other modern seas*.

The section which follows may help to a right notion of these relations, the red and gray chalk being always conformed to the white chalk, and, in fact, a part of the mass; while the Speeton clay and all the strata below are usually in unconformable positions, and have different strikes and angles of inclination. In point of direction of outcrop, however, the Speeton clay holds a parallel course to the north part of the wold, if we may judge by the two points (Speeton and Knapton) where it is best known.

* The discoveries of Dr. Carpenter and Professor W. Thomson by means of the deep-sea dredge are here alluded to.

*Section of the Cretaceous Series in Yorkshire, with the subjacent Strata.*

| | Estimated thickness in feet. | Fossils. |
|---|---|---|
| Upper Chalk .......... | 100 | Rich in *Spongiadæ*, *Marsupites*, &c. |
| Middle Chalk with Flints.. | 400 | Few fossils. |
| Lower Chalk .......... | 100 | Few fossils. |
| Red and Grey Chalk .... | 50 | Many fossils: *Belemnites Listeri*. |
| Speeton Clay .......... | 200 | Fossils abundant: *Hamites*, *Exogyra*. |
| Portland band .......... | 5 | |
| Kimmeridge Clay ...... | 300 | Fossils abundant: *Amm. biplex*, *Ostrea deltoidea*. |

The Coralline Oolite Series below.

It will be observed that in this Section Upper Greensand and Lower Greensand are not admitted by name. Neither of these, in fact, is specifically represented in Yorkshire. On a general view, the whole series of deposits below the red chalk and above the coralline oolite must be regarded as a peculiar group of argillaceous sediments in a part of the sea removed from the littoral agencies to which the Greensands and their accompanying conglomerates are due.

# CHAPTER VII.

## HOLDERNESS.

HOLDERNESS, taken as a natural division, may be said to include the whole country lying between the eastern slope of the Yorkshire wolds, the German Ocean, and the channel of the Humber. Its western limit passes by Bridlington, Burton-Agnes, Driffield, Beswick, Beverley, and Cottingham, to Hessle; what may have been anciently its extent towards the east and south-east is not easily determined, because on these sides it is exposed to a turbulent sea, which its loose materials are ill calculated to resist. Its greatest length is somewhat less than forty miles, and its extreme breadth about sixteen. It includes about 380 square miles of surface, of which, perhaps, seventy square miles are marsh-land, relinquished by the sea, according to a regular process of nature, or reclaimed by the enterprising industry of man. The remainder of the surface, though, on a general view from the wold-hills above, it appears like one extended plain, is found, on closer inspection, to be remarkably undulated; and though no land in the whole district exceeds 140 feet in height, yet, as the valleys are often sunk to the level of the sea, the hills assume a degree of importance which a stranger would by no means expect.

The long gently curved line of coast, which is so remarkable a feature in the topography of Holderness, furnishes the most advantageous opportunity of examining its geological structure; for these cliffs, daily wasted by the sea, exhibit distinct sections of nearly all the materials that exist in the country. The drains which intersect the marshland, and the wells which have been found necessary in a country having few natural springs, complete the facilities for its investigation.

There is, perhaps, hardly any district in the island which displays in so striking a light the powerful effects of Pleistocene currents as Holderness; for in this country accumulations, from this cause, compose the whole mass of every hill, and form the deep foundation of every marsh. In the cliffs of the coast and in the gravel-pits of the interior, remains of extinct animals are frequently met with; and the interest which these discoveries cannot fail to excite is increased by the abundance of the alluvial deposits which have happened in the same country at various subsequent periods, and contain the bones of animals of a more recent date. The remains of creatures overwhelmed by the glacial and post-glacial floods, and of those which perished long afterwards, lie here not far asunder; on the neighbouring wolds are the burial-homes of the earliest British and the later Roman and Saxon settlers; the circumstances of their occurrence may be deliberately examined; and the contemplative mind is presented with a physical record of the principal changes to which the surface of the earth has been exposed in these regions from those early periods to the present day.

Throughout the eastern parts of Yorkshire the detritus left by these remarkable floods has so much of a common character, and such relations to the existing and extinct races of land animals and the physical features of the region, as to mark *in this country* a definite geological æra, which in a vague manner has been called the "glacial" æra. But it is more convenient to regard the whole long series of geological events which have occurred since the deposit of Crag, as belonging to the Pleistocene or latest Cainozoic period, and to employ for subdivision the terms Preglacial, Glacial, and Postglacial *.

Wherever in Holderness the earth has been penetrated to a sufficient depth, pleistocene accumulations have been found in large quantity. However deep, in some instances, are the deposits of clay and peat in the sites of ancient lakes, and of silt in places overflowed by the tide, all these deposits rest on a basis of clay or gravel bearing marks of sea-drift,

* See Rivers, Mountains, and Sea-Coast of Yorkshire, ed. 1, 1853, p. 183, for the suggestion of these terms.

or shore agitation. Some confusion formerly existed concerning this matter, and, in consequence, mistakes were committed with respect to the antiquity of the deposits of peat and timber which are so frequent on the Yorkshire coast. Thus, in the Philosophical Mazazine for April, 1827, Mr. R. Taylor, comparing the subterranean forest, as it was called, of the Yorkshire coast to that of East Norfolk, is led to suppose that both these accumulations of timber, with all their imbedded bones, took place before the dispersion of what was called the "diluvial" detritus. Accepting to some extent the conclusion concerning the submarine forests of East Norfolk, I venture at once to affirm that the subterranean and submarine forests of East Yorkshire grew at a later epoch. Of this satisfactory proofs will be adduced, when I come to describe particularly the appearances on the coast; it may therefore be sufficient now to state that in several places the timber, peat, shells, and sediment which together make up the lacustrine deposits, are seen resting on a depressed part of the "diluvial" clay and gravel, and in some instances alternating with the upper parts of these deposits, but never entirely below them. For the same reason, then, that these accumulations are admitted to be posterior to the rocks which they cover, we must allow that the subterranean peat and timber are of still later date.

PREGLACIAL DEPOSITS.—The lowest of all the accumulations which rest upon the Chalk of the Wolds is an irregular layer of fragments of chalk and flint, which, being derived from the stratum beneath, are very little water-worn. This singular deposit seems due to a less violent action of running water than the general mass of heterogeneous pebbles which covers it. It seems to indicate a local agency of dispersion, perhaps the atmospheric waste of a terrestrial surface. Limited glacial or terrestrial action (sheets of ice or heavy inundations descending from the Wolds) may be suggested for the origin of the materials; but the distribution of them must probably be referred to the sea sweeping over the surface of the submerged land. I am not aware that any remains of land animals have occurred in this rubbly deposit, near Flamborough or on the Wolds; but at Hessle a deposit of the same kind, which I

suppose to be of equal antiquity, contains the teeth and bones of the extremities of horse, ox, and deer, very little worn by attrition. These bones, therefore, belonged to animals residing in the neighbourhood, they indicate a land-surface near; and as they are now covered up by a great thickness of clay and pebbles, derived from a far greater distance, we count them the spoils of preglacial land. The rubbly layer of chalk and flint fragments is not common on the highest parts of the Wold-hills, but has been drifted chiefly to the lower part of their slopes.

BOULDER-CLAY, GLACIAL DEPOSITS.—The thickest and most extensive of the diluvial accumulations in Holderness is a mass of clay enclosing angular and abraded stones of many kinds derived from different regions. In the cliffs north of Bridlington and at Hessle, it is seen to cover immediately the water-moved rubbly chalk and flint, which lie on the great stratum of Chalk. It extends in a connected mass, under nearly all Holderness, forming most of the hills and "hard land," and underlying most of the accumulations of gravel and alluvial sediment. In the highest cliffs on this coast its thickness is not less than 130 feet. Its composition is remarkably uniform. We every where observe it to be a solid body of clay, containing fragments of many kinds of rocks, which vary in magnitude and in the degree of roundness to which they have been reduced. The fragments are, in general, not so numerous as to touch each other, nor placed in continuous layers, but are scattered through the clay as plums in a pudding. In the midst of the deposit they are sometimes aggregated into distinct layers of gravel, which continue for a sufficient distance to furnish springs of good water. Thus the clay appears to be divided into two parts, a circumstance observable in Holderness, and in the cliffs of Filey, Scarborough, and Whitby. The rocks from which the fragments appear to have been transported are found—some in Norway, in the highlands of Scotland, and in the mountains of Cumberland, others in the north-western and western parts of Yorkshire; and no inconsiderable portion appears to have come from the sea-coast of Durham and the neighbourhood of Whitby. Some ground appears for thinking that in proportion to the distance which they have

travelled is the degree of roundness which they have acquired. All the smaller fragments of granite, porphyry, mica-slate, and clay-slate, which can be compared with no fixed rocks nearer than those of Scotland or Cumberland and Westmoreland, are rolled to pebbles; the angles are worn away from every small mass of limestone which has been drifted from the north-western hills of Yorkshire; while those which have been brought from the nearer points of the chalk range have yielded much less to attrition. Some attention is required to the original hardness of the stones: limestone is less rounded than millstone-grit; and flint retains uninjured angles, whilst chalk and magnesian-limestone have lost their original surfaces, and laminated fragments of Lias shales have become ellipsoidal. Some of the stones are scratched; more are smoothed on one or more faces; but, except in the interposed or covering gravels, few are rounded to pebbles.

Few substances originally soft are carried by water to a great distance, in a solid form. The sandstones of the western and north-western parts of Yorkshire are plentiful in the gravel of the Vale of York; but only the hard "galliard" of Leeds and Bradford, and the solid millstone-grit of the moors, can be recognized in the clay of Holderness. This clay is itself, no doubt, an aggregate principally of the particles into which the softer strata exposed to the ravages of ice or water have been resolved. Its vast bulk need not surprise us, when we remember the distance traversed by the currents, and consider how large a portion of the mass removed was clay and disintegrated sand. We might have expected to find these finer particles at the top, and the solid fragments of rocks lying beneath, according to their individual magnitude and weight. As nothing of this kind is observable, we must suppose the fragments to have been heaped together by some other process than water-drifting, and to have been very little influenced in their arrangement by specific gravity or difference of bulk. The larger blocks which are occasionally found in the clay are usually but little worn; such rarely occur in the gravel-beds, in which generally the fragments are smaller and much more rounded than in the clay.

The various organic remains which lie scattered in this clay must be considered in two very distinct groups—those which were removed from rocks in which they had been previously entombed, and others which belonged to animals on the earth, or in the sea, coeval with the deposit. To the former class appertain corals from the Mountain-limestone, plants from the Coal series, Ammonites, Belemnites, Gryphites, and many other shells from the Lias; and Belemnites, Echini, and Inocerami from the Chalk. These remains furnish very important evidence towards determining the direction of the glacial currents.

But the other class of remains, the bones of animals which were in existence in these regions during the detrital period, and the shells which, during the agitation, were buried in sediments or dragged up from the deep and mixed with the general spoils of the land, lead us to still more interesting conclusions. For when among hard stones which have been worn to pebbles we find the tusks, teeth, and bones of pleistocene quadrupeds comparatively uninjured, retaining their characteristic shape and often their original surface, we must surely be convinced that such remains have not been removed far from the places where the animals lived. The only reliquiæ of this kind which I have been able to assure myself were found in this clay, are those of the Mammoth (*Elephas primigenius*). Teeth and tusks of this animal have been collected in several places on the sea-coast (mostly in gravel); and I once found a small fragment of a tusk at Hessle. This mammaliferous deposit is not confined to the flat district of Holderness, but is found in some of the valleys of the Wolds, thus indicating the extent of the watery action, and determining the minimum of antiquity of these valleys.

GRAVEL-BEDS.—It was observed that, occasionally, patches of gravel and sand were found lying enclosed in the great deposit of clay. Such are seen in many places on the sea-coast, particularly near Dimlington, near Skipsea, and toward Bridlington. In many situations gravel-beds cover the Boulder-clay, and are filled with pebbles derived from that singular mass. In several places, inland, these accumulations are more considerable, and compose hills of a remarkable appearance, as at

Brandesburton, and in the neighbourhood of Paghill and Keyingham. An elephant's tusk has been found at Brandesburton; and in the neighbourhood of the latter places I have observed abundance of marine shells, intermixed with the gravel. As this occurrence is seldom witnessed, it may be proper to give the results of a careful examination of the attendant circumstances.

Some vague reports concerning these shells induced Mr. Smith to consider them indications of the Crag formation; and he expressed this opinion on his Geological Map of Yorkshire (1821). In 1824 I saw specimens collected by Mr. Smith and Mr. Salmond, from a situation which will be described; and I was immediately convinced that they were not specifically distinct from shells now common in our own seas, and therefore felt unwilling to believe that they were of such great antiquity. This opinion was proved correct by an examination of the locality in 1828. About a mile south of the house of my kind friend, Mr. Stickney, of Ridgemont, near Hedon, is a large excavation, from which gravel has been obtained for the neighbouring roads. The highest point of the hill in which the excavation is made, is 36 feet above the adjacent marhsland, which Mr. S. informs me is 5 feet below the level of high water at spring tide; and the pit is sunk down to the level of the marshes. Sand, pebbles, and marine shells of comparatively recent, and water-worn fossils of more ancient date, are here mixed together, in confused and irregular layers. The pebbles and fossils may be clearly identified with the Chalk and Flint of the Wolds, the Lias and Oolite of the coast near Whitby, the Magnesian limestone near Sunderland, the Coal and Limestone series of western Yorkshire, as well as the "Grauwacke" and other slate-rocks, with porphyry, granite, &c., of Cumberland and Westmoreland.

Amidst this heterogeneous mass, which indicates such various and violent currents of water, it is remarkable that we find many rather delicate marine shells in tolerable perfection. Besides the strong shells of *Turbo littoreus*, *Purpura lapillus*, and *Buccinum undatum*, we have *Mya arenaria*, *Tellina solidula* and *T. tenuis*, *Mactra subtruncata*?, *Cardium*

*edule*, and a shell which, in an imperfect state, appeared to be *Crassina Scotica*, but is certainly of a different genus*. The shells are most abundant along particular layers in the gravel. The mass descends to a great depth, and is found beneath the adjacent marshland, which consists of fine clay, lying upon peat and trees, and is part of an extended level tract reaching from the Humber, near Pattrington, almost to the sea, at Sandley mere. It seems to have been at some former period a channel for some vast volume of water; for it winds as other valleys do, and the gravel hills which bound it are abrupt on the concave side, and slope gently down on the other.

In the cliffs against the Humber, at Paghill, very similar phenomena are observed. The gravel and sand are here remarkably contorted, and intermixed with alternating layers of a sediment much like warp. The shells are of the same kinds as in the pit near Ridgemont, in similar disorder, and equally plentiful. The pebbles and fossils mixed with them are also very similar; but the masses are generally very small, and flint is more abundant—a circumstance probably depending on the proximity of the Chalk Wolds.

Since these observations were written (in 1828) the spot has been revisited by Mr. Prestwich and other geologists, and more detailed lists of the shells have been published. When the sections of the coast come to be considered, this interesting deposit will derive some illustration from other examples of shell-deposits connected with the boulder-clays and gravels.

POSTGLACIAL DEPOSITS, ALLUVIUM.—The alterations in the form of land occasioned by ice-action and water-force during the Glacial period must have been considerable, but not such as greatly to alter the main features of the physical geography of Yorkshire. The operation of natural causes since that period deserves to be maturely considered; for these have materially changed the local aspect of the region. The lakes, which

* It is now known as *Cyrena fluminalis*.

were left on the last retiring of the sea, appear to have been continually diminished in depth and contracted in extent by deposits of vegetable matter, accumulated shells, and sediment brought into them by land-floods. In this manner many inland lakes have been extinguished in Holderness; and nothing remains to denote their former existence but the deposits by which they have been filled. The earliest observers of this coast bestowed very little attention on the lacustrine deposits, which appear so frequently on the cliffs and exhibit so convincingly the proof of long-elapsed time since the date of the fundamental boulder formation. To amend, in some degree, this defect, I propose to enumerate and describe them pretty minutely in my observations on the section; but it will be desirable to sketch a general outline of their characters here, and to put them in comparison with the contemporaneous marine deposits, which are so remarkable on the shores of the Humber.

All the lacustrine deposits containing peat which I have inspected in Holderness agree in this general fact, that the peat does not rest immediately upon the boulder formation beneath, but is separated from it by at least one layer of sediment, which is seldom without freshwater shells. The peat is generally confined to a single layer; and shells are seldom found above it. Supposing that all the varieties which I have witnessed in different places existed together, the section would be nearly in the following general terms:—

1. Clay, generally of a blue colour and fine texture.
2. Peat, with various roots and plants, and, in large deposits, containing abundance of trees, nuts, antlers of deer, bones of oxen, &c.
3. Clay of different colours, with freshwater *Limnææ*.
4. Peat, as above.
5. Clay, with freshwater *Cyclades* &c. and blue phosphate of iron.
6. Shaly curled bituminous clay.
7. Sandy coarse laminated clay, filling hollows in the diluvial formation.

Of these the most constant beds appear to be Nos. 1, 2, and 5; and in general these constitute the whole deposit. In different places the layers exhibit much diversity of colour, consistence, and thickness. The peat

varies in its thickness from five feet to less than as many inches, and its constituent parts seem not the same: in a few instances there are no shells in the lower clay; and when they do occur they are sometimes of different kinds; Cyclades and Paludinæ are most plentiful. Anodons occur in it at Owthorne, Hornsea, and Skipsea; but I did not find them elsewhere.

The trees and shrubs found in the peaty tracts near Hull, Beverley, and Hornsea are all of species now growing in neighbouring parts of Yorkshire, though some of them are but rarely seen in the "Isles of Holderness," except in plantations. They have been in most cases displaced, but not removed far from their original site; they are laid prostrate, in some confusion, as if they had fallen through decay, or been overthrown by wind from the S.W. In a remarkable example which was laid open by cutting a deep drain in Waghen Fen, near Beverley, yews, birches, oaks, firs, alders, and hazels, with nuts, acorns, and land-shells, were found lying one over another in extensive layers, the sorts of trees so far distinct as to indicate successive deposition. Yew-trees were at the bottom, oaks, alders, and hazels were above, and on the surface were old stumps of Scotch fir in attitude of growth. Yew-trees are not, I believe, known in Holderness as native trees; one might rather look for them amidst the wolds, or on the cliffs of limestone at Roche Abbey, than in marshy ground so near to the sea. Yet it is conceivable that in former times, when Holderness extended some miles further to the east, a grove of yews may have lived in Waghen Fen, as now they do in a peaty tract near Rossington Bridge*.

The quadrupedal remains which have been found in this lacustrine formation belong principally to deer. Bones of oxen likewise occur in it. Of deer at least three species have been discovered in the postglacial peat and clay of Yorkshire. The great Irish elk (*C. giganteus*) has been found at Skipsea and near Wetherby; the red deer (*C. elaphus*) is common in many situations; and a species of the size of the fallow deer (*C. dama*)

* Phillips, "On the Ancient and Partly-buried Forests of Holderness," Philosophical Magazine, 1834.

is reported from Hatfield Chace. A doubtful skull (found at Owthorne), in the possession of the Yorkshire Philosophical Society, has some resemblance to the cranium of the chamois.

The extensive accumulations of peat and trees along the shores of the Humber and its tributary rivers happened, probably, at the same period of time as those which have contributed to fill up the ancient lakes of Holderness. This is inferred, with great probability of truth, from the position of the peat with respect to the boulder-clay and pebbles; for wherever these occur together, the former is invariably uppermost. The opinion of the peat extending under the whole district of Holderness, was probably founded on the very considerable depth at which it is, in some places, buried under sediment deposited by the sea. But this silt, accumulated by the action of the tide, which composes the surface of the level land in Holderness, may be easily distinguished from the more ancient aggregations of clay, sand, and pebbles which belong to the glacial formation. No freshwater shells, nor any such alternations of argillaceous marls as those which lie in the site of former lakes, accompany the peat deposit of the marshlands; but it is covered by a marine deposit of silt and clay, such as now drops from the muddy waters of the Humber, and occasionally yields a few littoral shells, as *Tellina tenuis*. The depth of this covering is in some instances not less than thirty feet; and the peat lies below the low-water mark. Under what circumstances it was collected together, unless changes of the relative levels of land and sea be allowed, it is not easy to conjecture. That at the time of its aggregation the sea flowed up the channel of the Humber appears probable, because the first deposits which cover it are of the same kind as those now dropped by the tide; that its formation happened soon after the glacial era, may be inferred from the fact that it rests almost immediately upon the diluvial detritus; that some remarkable general agency, possibly a great land-flood, was concerned in the production of the phenomena, is evident from the extent of the vegetable accumulation.

The following statement of substances, found in sinking a well at the Block-house mill, on the east side of the town of Hull, derived from two

accounts communicated at different times by my friends, will show what are the accompaniments of this remarkable layer of peat in Holderness:—

| | | feet. | | | feet. |
|---|---|---|---|---|---|
| *Alluvial deposit.* | Soil | 1 | | | 32 |
| | Clay | 6 | | | |
| | Silt sand | 23 | | | |
| | Moor or peat, with large trees &c. | 2 | | | |
| | | ft. | in. | | |
| *Diluvial deposit.* | Blue clay | 1 | 6 | Mixed with chalk fragments, carbonized wood, &c. | 62 |
| | Brown clay | 22 | 6 | | |
| | Loamy clay | 12 | 0 | | |
| | Quicksand | 26 | 0 | | |
| | Chalk | | | | 16 |
| | | | | Total depth | 110 |

In Ottringham Marsh the layer of peat, one yard thick, was found *forty-one yards* beneath the surface; thirty-six yards of various diluvial matter lay beneath; and the chalk was found at the depth of seventy-eight yards.

These accounts are interesting in another point of view; for, by means of them, we can determine correctly the dip or inclination of the chalk. The nearest situations where this stratum sinks below the marshland are at Hessle and Cottingham. The distance between Hessle and the Block-house mill, in a straight line, is between four and five miles; and as the upper plane of the chalk was found in the latter instance ninety-four feet deep, whilst at the former point it appears at the surface, the dip towards the east is twenty feet per mile. The distance from Hessle to Ottringham marsh is nearly fourteen miles, and the inclination 234 feet, or sixteen feet per mile. If this moderate declination be constant, the chalk rock may be reached by wells in many parts of Holderness, and thus, as in similar districts of Lincolnshire, unfailing supplies of water be obtained.

## CHAPTER VIII.

### THE YORKSHIRE COAST, FROM SPURN POINT TO BRIDLINGTON.

BEFORE entering on a particular description of all the cliffs on the sea-coast of Yorkshire, it seems necessary to give a general explanation of the section which is drawn to represent them; for this is not a hasty sketch, designed merely to give a rude notion of the height and stratification of the cliffs, but carefully constructed from many and repeated measurements. It was originally drawn on a much larger size than it would have been practicable to publish; but it is hoped the scale here adopted will be found at once sufficient and convenient. A mile in length of the coast, allowing for its principal flexures, occupies in the section $1\frac{1}{2}$ inch; and 400 feet of altitude are represented by 1 inch. This is quite sufficient to allow of expressing all details necessary to a proper exhibition of the principal strata, in their relative order and thickness. Wherever the nature of the subject requires it, enlarged drawings are added, with proper marks of reference to their place in the general section. For this purpose, the junctions of rocks have been very carefully studied and copied on the spot, and all their minuter peculiarities recorded. Upwards of fifty such detailed sections have been drawn, but it has not been deemed requisite to engrave so many. Such of them have, therefore, been selected as seemed to be most illustrative; and these, with the accompanying explanations, will, it is hoped, be found sufficient to give an accurate knowledge of the coast.

The heights of the cliffs are represented above the level of high water at spring tide, because this is, upon the whole, the most convenient line that can be referred to; and though it is too variable to serve for the rigorous determination of altitude by graduated instruments, it will be

K 2

found accurate enough for geological purposes*. The tides rise on this coast about 15 or 18 feet; and as they very generally lay up much sand at the foot of the cliffs, and as at this level we commonly find much *débris* accumulated, it seemed, upon the whole, better, except in a few instances, to confine the colouring to the level of high water. The letters placed on the sections of the Holderness coast are referred to in the text. It remains to state that the following description is in every particular original; and was mostly executed on the spot.

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### SPURN POINT.

The southernmost part of the coast of Yorkshire is a low peninsula of gravel and sand, accumulated by the sea and the wind, and laid in its peculiar forms by the united action of currents from the sea and the Humber. The materials which fall from the wasting cliffs between Bridlington and Kilnsea are sorted by the tide according to their weight and magnitude; the pebbles are strewed upon the shore, beneath the precipice from which they fell; the sand is driven along and accumulated in little bays and recesses; whilst the lighter particles of clay are transported away to the south, making muddy water, and finally settle on the growing boundary of Lincolnshire, or enter the great estuary of the Humber, to enrich the level lands under the denomination of warp. The sand and pebbles, which were at first deposited near the place where they fell, are afterwards removed further and further south by the tide, and the cliffs are left exposed to fresh destruction. Thus the whole shore is in motion, every cliff is hastening to its fall, the parishes are contracted, the churches washed away, and not unreasonable fears are entertained

* These heights were determined entirely by barometrical methods, often repeated, to overcome the special difficulties which occur to measures of this kind on a steep sea-coast with strong currents of wind; many of the points whose elevations were determined by me, have been since subjected to exact levelling by the Ordnance Survey. Where the differences by these different methods appear considerable they will be noticed.

that at some time the waters of the ocean and the Humber may join across Holderness, and the Spurn become an island. At present, however, the isthmus, though continually disturbed at the edges, stands firm round the Pharos, and though composed only of a heap of pebbles and sand, and exposed to two strong currents, may, perhaps, be little changed for ages to come: such is the efficacy of long equal slopes and a pebbly sand in repelling the rage of the sea.

Among innumerable pebbles derived from the wasted cliffs of Holderness, which are here thrown up by the sea, at Spurn, we observe:—diallage rock, mica-slate with garnets, and a great variety of diorites, greenstones, and porphyries, which have been vaguely referred to Scotland, and perhaps Norway; much granite from Shap fell, syenite from Carrock fell, breccia from Kirby Stephen, and other Cumbrian rocks; limestone and sandstone from the western part of Yorkshire; and Lias fossils from the neighbourhood of Whitby.

From Spurn Point to Kilnsea the shore is very low, and, being composed only of gravel and sand, presents little that requires remark. The ruins of Kilnsea Church stand upon a low perishing cliff, of very peculiar composition. Not a single pebble is to be seen in it, but the whole height is a mass of loam or warp, disposed in regular laminæ, whose parallel surfaces are undulated like the broadest ripple-marks on a level sand. In Plate XXI. (A) is a sketch to show the peculiar arrangement of these undulations; and it must be noticed that, in the sharper curves, the laminæ are separated a little from each other (*a*).

This deposit has so different an aspect from the usual appearance of the drift-clay in the cliffs of Holderness, that it might rather seem of quite a different origin, the result of some intermittent overflows of the sea at a higher level than it now attains except in storms. We shall find further opportunities of examining this question when we come to mention similar phenomena near Bridlington.

From Kilnsea to where the road goes from the shore to Easington, the coast is an extended beach of pebbles and sand, which opposes a low barrier to the union of the sea and the Humber; but from this point

cliffs arise, higher and higher, till they reach Dimlington height, which is the loftiest point in Holderness. The beacon here appears about 139 feet above high water; and the whole cliff is composed of clay with stones scattered through it, and interlaminations of small seams of gravel, yielding water. Here the wasteful action of the sea is very conspicuous: the sand and pebbles being removed from the base of the cliffs by the southward set of the tide, vast masses are undermined, and fall in wild and ruinous heaps; these, as they gradually reach the base, are washed away, and the process of destruction is repeated.

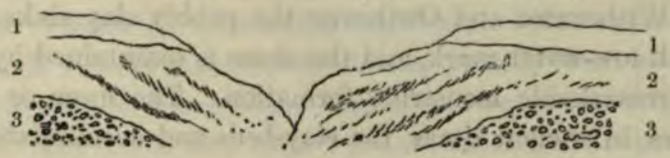
In my early examination of this great mass of drifted materials, I remarked a difference of colour between the upper and lower parts of the clay. The upper clay, which forms the greater part of the "diluvial" cliffs on the whole Yorkshire coast, is of a brown or purplish hue, often with blue surfaces to the fissures; the lower part, which appears at intervals along the coast from Dimlington to Mappleton, is of a decided blue tint*. Recently Mr. Searles Wood, jun., and Mr. Rome have described these as two distinct boulder-clays of different geological age, and often separated by a band of gravel and sand†. And at the base of Dimlington cliff, Mr. Leonard Lyell has discovered a sandy layer with plenty of *Nucula Cobboldiæ*, a shell often regarded as characteristic of the Suffolk Crag. Two other examples of shelly deposits in connexion with the glacial drift will come under notice as we proceed, and furnish further data for discussion as to their age and relation to the Crag and later deposits.

From Dimlington height the cliffs descend to Out-Newton, where they are about 30 feet high. In this part we remark a good deal of gravel deposited in layers, chiefly above, but sometimes in the midst of the clay. The most remarkable appearance of this kind is represented in the sketch (B), Plate XXI. Here, near the surface, is a mass of sand and small gravel, 5 feet thick, in irregular layers, resting upon a bed of coarse gravel, 4 feet thick; below this comes a layer, 4 feet thick, of sand and small gravel, in highly inclined layers; still lower, a repetition of the coarse gravel, 5 feet thick, and a third series of obliquely laminated sand, the whole resting upon the blue stone-spotted clay, the lowest

* MS. Notes, 1828. † Proc. of Geol. Soc. 1868.

glacial deposit in Holderness. Near this place (further north) we observe a quantity of gravel in irregular layers, poured, as it were, into a cavity in the pebbly clay, which descends below low-water mark, and indicates local excavation by currents before the deposition of the gravel and sand. Pale lacustrine marls appear obscurely above. The diagram which represents this occurrence is taken from my Note-book, 1826.

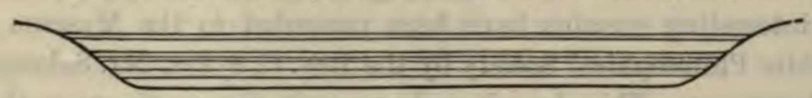
*Gravel-deposit in a hollow of Boulder-clay*, 1826.




1. Pale clay. 2. Yellowish sand and gravel. 3. Blue boulder-clay, with various stones imbedded.

Between Out-Newton and Hólympton we are surprised by the appearance of a distinctly freshwater deposit of marly clay on the top of the cliff, about 20 feet above high water. As many of these interesting deposits will claim our attention, I shall be obliged to restrict my description to those which exhibit the most important characters, and to barely notice others of minor interest. We shall therefore proceed about half a mile further, to about opposite Holympton, where the cliffs are lower and a more extended lacustrine deposit appears in a hollow of the diluvium. The length of this deposit is about 200 yards, and its extreme

*Lacustrine deposit of Holympton, in a hollow of Boulder-clay*, 1826.



height above the sea about 10 feet. It rests in a hollow of the pebbly clay, which abounds along the shore, and consists, under the thin brown soil, of seven distinct layers of clay, the lowest of which contains *Cyclades* and *Paludina tentaculata*, and the lowest but one roots of plants but no peat. The layers are thus arranged :—

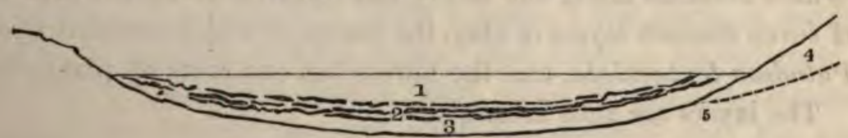
*Lacustrine deposit.*—Brown soil. Bluish bed of argillaceous marl. Shaly clay, changing upwards to white clay-marl. Shaly bed of clay. Blue and brown clay-marl.

Black marl, with plant-roots. Grey marl, with *Cyclades* and *Paludinæ,* which inhabited the lake. *Diluvial* clay, with pebbles of quartz, slate, and greenstone.

Beyond Holympton the cliff, though still low, rises a little toward Owthorne, and displays, in little hollows, two other deposits of laminated clay, indicating the sites of ancient lakes. Of these, the southern is twelve yards across, the other, near Withernsea, one hundred yards.

Between Withernsea and Owthorne the pebbly clay sinks very much, even beneath low-water mark, and the shore is maintained by the broken edges of a remarkable lacustrine formation. The mere or lake, under whose waters, in ancient times, the clay-beds and accumulations of peat and trees were here laid in a regular series, is still represented by a little reedy flat, partly covered by drifted sand. It has been conjectured that this little flat is a continuation of the winding level in which the Winestead drain is excavated, and that in this direction the sea once joined the Humber. But it appears to me that this ancient lake was never connected with the Winestead level, but poured its waters into the sea, under the protection of cliffs which are no longer in existence. The sea-line, at low-water, now crosses the middle of the ancient lake, and washes the deposits which happened within it. At the bottom, immediately upon the pebbly diluvial clay, we find some blue lacustrine clay, containing small specimens of *Anodon anatinus*; above this lies a vast quantity of peaty matter full of hazel-nuts and branches of trees; more rarely the bones of terrestrial animals occur, especially of the stag. Specimens of these interesting remains have been presented to the Museum of the Yorkshire Philosophical Society by the Rev. C. Sykes, Mr. Salmond, and Mr. Backhouse. This deposit ends towards the north, near the little

*Peat- and Shell-deposit above Boulder-clay,* 1826, *between Withernsea and Owthorne.*




1. Blown sand. 2. Peat, branches of trees, &c. 3. Blue clay, with *Anodon.* 4. Brown clay and stones. 5. Blue clay and stones (Note-book, 1826).

projecting cliff, which was all that remained of the churchyard of Owthorne in 1828, the church having been some time washed away and the churchyard so rapidly wasted that all the gravestones had been removed (1828)*. The buried bones of former generations, which were seen projecting from the crumbling cliff, had a singular appearance, and, combined with the falling of the cliff and the roar of the destroying waves, filled the contemplative mind with solemn and awful reflections.

The cliffs at Withernsea, composed of reddish-brown clay, are stained blue in the fissures by descending rain-water. Numerous fragments of stone of small size lie scattered in the clay, mostly worn at the angles, in extreme cases reduced to pebbles. Among them we recognize:—pieces of hard chalk, sometimes very little worn, as much as 7 inches across; flint fragments, jet, oolitic and liassic stones and fossils, especially *Gryphæa incurva*, Ammonites, and Belemnites (the origin of these masses is certainly from the neighbouring north); sandstone of red, yellow, and grey tints, hard "Grauwacke" like that of the Lammermuir, 6 inches across, gneiss, granite, purple and green slates, flinty slate, quartzite, &c., quartz, jasper, felspathic porphyry, amygdaloid, aphanite (for which the most probable local origin is toward the north-west, but not exclusively the Cumbrian mountains); Carboniferous limestone with Productæ and Corals, coal, ironstone, and sandstone of the Coal-measures with *Stigmaria* (which seem to be drifts from the north-western parts of Yorkshire). I saw no Shap granite, no gneiss, no mica-schist. What natural operations could bring these fragments together? by what agency could they be dispersed irregularly in this mass of clay? We must pause and examine other cliffs before attempting to reply. Magnetic ironsand occurs in plenty on the shore north of the esplanade of Withernsea.

Between Owthorne and Sandley Mere the cliff attains an elevation of 35 feet, and is composed of brown and blue clay, with various pebbles,

* On my first visit to Owthorne (1826) two gravestones remained in the wasted churchyard: on one was an inscription containing the line, "I must lie here till Christ appear;" in 1872 the whole is changed to a promenade, which extends across and conceals the lacustrine deposit and unites the boundary cliffs for the convenience of the numerous visitors to what was formerly one of the loneliest spots in Holderness.

chalk, coal, &c., scattered through it. Two hundred yards south of Sandley Mere is a layer of gravel in the clay, which produces a copious spring (F, Plate XV.). Wells sunk in the diluvial tracts of Holderness seldom fail to produce water when they touch a bed of gravel.

Sandley Mere, as its name implies, was formerly a lake; it is now (1828) a reedy flat, protected from the sea by only a broad beach of sand and pebbles, thrown up by the tide. Sometimes storm-swollen waves, rushing over this unsettled barrier, enter the ancient mere, and would flow down the marshy level of the Keyingham drainage, by Rooss and Ridgemont, to the Humber, but for an artificial bank constructed under the management of the Commissioners of Sewers. As at Owthorne, the sea now flows over a part of the ancient bed of Sandley Mere, and covers with sand much of its clay and peat. In this lacustrine formation the bones of oxen and deer, with antlers of the stag &c., have been at different times discovered. The boulder-clay cliffs also furnish teeth of the elephant in considerable plenty, which, being commonly picked up on the sand, are more or less worn by friction among the pebbles. It is remarkable that no other parts of the skeleton are found here.

The cliffs north of Sandley Mere rise gradually, and, opposite Hilston, are about 80 feet high. Where they reach the height of 69 feet, a very interesting deposit of freshwater clay and shells appears on the top for the length of 200 feet (see section G, Plate XXI.). Its thickness is 4 feet 8 inches; the upper 2 feet 6 inches consist of fine clay; below are 6 inches of peat, then 6 inches of clay perforated by roots, next 8 inches of clay with plenty of *Limnæa stagnalis*, 2 inches of peat, and 4 inches of a soft yellowish earth. Beneath this deposit is the blue pebbly clay, which forms the mass of the cliffs.

Beyond Hilston, as far as Grimston Garth, the cliff maintains the same composition, and, with some undulations, keeps the same elevation; but towards Ringbrough it falls, and becomes still lower beyond. Here a layer of gravel appears in the midst of the clay. Opposite East Newton the cliff is, at the utmost, 67 feet high, but between this and Bunker's

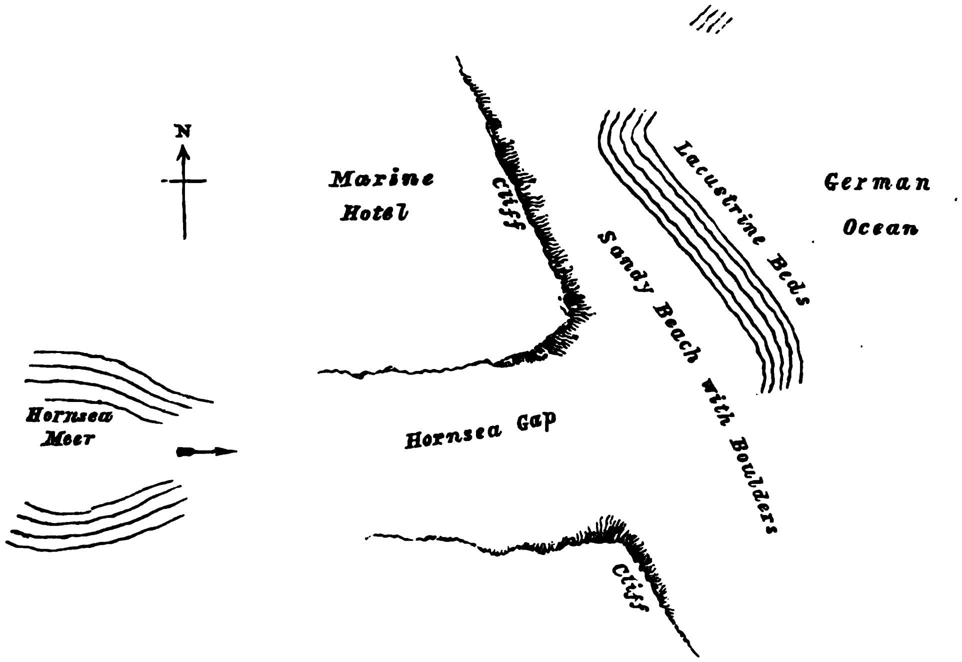
Hill it falls to 40 feet, and is covered by freshwater deposits of clay with blue phosphate of iron, peat, and curled black shale (H in Plate XXI.). The peat has produced abundance of hazel-nuts. Bunker's Hill, which is on the north, is 79 feet high; from hence the cliff preserves, by Great Cowton and Mappleton, a nearly uniform height of 60 feet, till it sinks to the wide hollow opposite Hornsea. The general base of this whole cliff is the same blue and brown diluvial pebbly clay; and the only change in its appearance which strikes the attention is a more abundant diffusion of chalk-pebbles in the northern part. It is almost invariably the case that the blue part of this clay is at the bottom, and the brown above; but the joints of the brown variety are very often stained blue, apparently by water passing down them. At Great Cowton a quantity of gravel lies above the brown clay; and in going along the shore, beyond Mappleton, I observed four separate freshwater deposits on the top of the cliff, and in the middle of the clay a continuous seam of gravel. Similar appearances continue to Hornsea.

The streams which pass by Hornsea fall into the sea through a wide depression of the cliffs, called Hornsea Gap. The well-known lake called Hornsea Mere is one of the few sheets of water now remaining in Holderness, of the many which once existed there. When, if ever, in future ages the wasting action of the sea shall have extended inland so far as to reach and empty this lake, its bed, partly uncovered at low water, will resemble the bottoms of Owthorne and Sandley meres.

On this point no doubt will remain in the mind of the observer who may have the good fortune which befell me this year (July 1872) of seeing the plant and shell-beds, which correspond to many so-called "submarine forests," well exposed at low water of spring tides for a length of 300 or 400 yards, at a distance of 50 to 200 yards from the gravelly cliffs of Hornsea. The map which follows will give a fair idea of the relative situation of Hornsea Mere, with its discharge opening through Hornsea Gap, and the continuation of the ancient line of drainage through the lacustrine deposit of shelly clays, with drifted plants and wood, which occupied the bed of an ancient mere, on the line of postglacial drain-

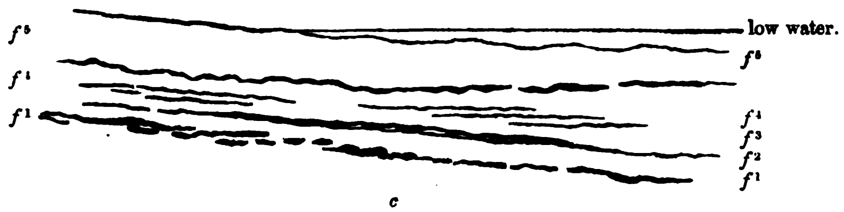
age from the existing lake. The drainage appears to have turned north-eastward after passing Hornsea Gap, and to have met the sea far to the eastward of the present line of cliffs.

*Map of a Part of the Coast at Hornsea* (1872).




The deposits of this ancient mere present the following section—the beds being perfectly traced and measured in consequence of a gentle dip seaward, which indicates that we are looking at the landward side of the old lake :—

*Submarine Plant- and Shell-beds at Hornsea* (1872).




These freshwater deposits, taken in the order given above, downward, may be thus described :—

$f^5$. Blue clay-bed, 2 or 3 feet; at its base a layer of plants with small peb-

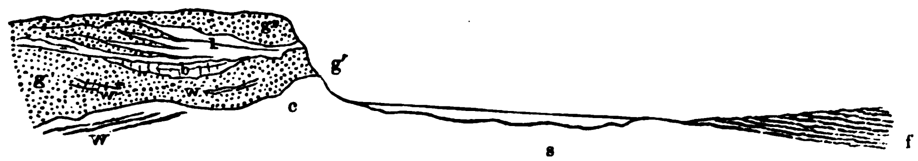
bles. In it roots and stems and a remarkable straight piece of fir wood, smoothed to a tapering elliptical section, 5 feet long, was found in the clay. It was perforated by boring shells, and marked at one point by blue phosphate of iron; a lump of iron-pyrites was found, but no fabricated iron was seen. A portion of the wood was taken as a specimen to the Oxford Museum.

| | | |
|---|---|---|
| $f^4$. | Brown clay-bed, 1 to 3 feet, unequal; in it shells of *Anodon* are common, with the epidermis preserved. | in. in. |
| $f^3$. | Laminated plant-bed, occasionally peaty . . . . . . . . . . . . | 0 to 3 |
| $f^2$. | *Cyclas*-marls, of pale brown tint, mixed with $f^3$. Small *Paludinæ* occur in abundance . . . . . . . . . . . . . . . . . . . . | 4 to 12 |
| $f^1$. | Peat and black root-bed of irregular thickness and interrupted extent . | 0 to 6 |

Beneath, *c*, are the usual red-brown clay and pebbles without any intervening gravel or sand.

Looking up from this deposit, effected when the land of Holderness extended much further to the east, we behold at a higher level in the cliff other freshwater deposits of earlier date, lying over some and below other bands of the gravel which rests on the brown boulder-clay. The section is well exhibited, in a part of the cliff which has escaped the improvement of being scarped to a smooth slope and traversed by a path to the sea. Very possibly in a few years the curious appearances represented in the following two diagrams may be obliterated by further changes for the pleasure of bathers, but to the regret of geologists.

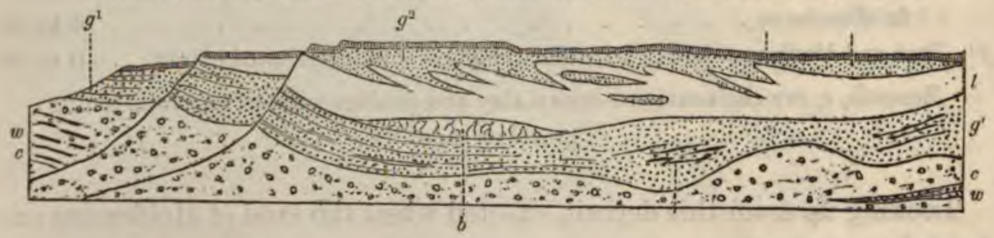
*Section of the Coast at Hornsea looking to the North* (1872).




s. Sandy and pebbly beach.
f. Submarine lacustrine beds.
g″. Gravel and sand of yellow tint, which partially alternates with the freshwater marls below.
l. Laminated pale marls or clays, sandy above, and alternating with the gravel, shelly toward the bottom, with crushed layers of *Chara* and a thin black peaty streak. Thin blue clay at the bottom, which rests on gravel.
g′. Irregular deposit of yellowish gravel, mostly small, with much sand and some thin limited bands of "warp." In one place rather larger stones than usual lie in an interrupted band on the clay.
b. Brown clay, "pipy," not laminated, analogous to the "seat earth of a coal-bed." No shells.
c. Stone-spotted boulder-clay, of a reddish-brown tint, irregular on its upper surface, and holding in places laminated beds of silt or "warp," marked *w*.

The complicated structures represented in the section below were traced with much care, under favourable circumstances, which allowed me to see clearly the digitated partial alternation of the upper lacustrine layer ($l$) with bands of the covering gravel ($g^2$) and the limited patches of gravel enclosed in the lacustrine beds. These, generally speaking, rested conformably on lower and more continuous gravel and sand, and were most shelly and characeous near the bottom. But in one place ($b$) brown clay

*Sketch of the Cliff (about* 15 *feet high) near the Marine Hotel, Hornsea* (1872).




intervenes, and is traversed by pipes marking the growth on it of some aquatic plants—a limited lacustrine sediment, in which no shells were found. In the gravel below ($g^1$) are several interposed bands of warp without shells; the lower surface follows the irregular swellings of the boulder-clay, which also has warp-beds ($w$) of considerable thickness in it, best seen toward the southern part of the cliff near the Marine Hotel. These laminated sandy deposits mark intervals in the accumulation of the drift, and may be expected to yield marine shells; but I found none.

The appearance of the cliff at this part of the coast has been somewhat altered since June 1828, when the following brief description was made on the spot.

North of Hornsea Gap, where a little gully divides the cliff, which is about 15 feet high, we observe a small lacustrine deposit, 30 yards long, consisting of the following series, beginning at the surface :—

*Lacustrine deposit.*—Brown clay and soil. Peaty earth. Brownish marl. White marl and shells, and plant roots. Beneath is gravel, resting on pebbly clay.

It is in fact changing from year to year by the operations of nature, which

tend to remove, and the constructions of engineers, which, often in vain, attempt to preserve; so great is the rage of the sea. The Rev. J. L. Rome observed, a few years since, at the base of the cliffs immediately north of the Marine Hotel, in addition to beds of loam intercalated in and false-bedded with the gravel, a loam-bed 6 feet thick occurring beneath the gravel, containing freshwater mollusca in great abundance. According to a sketch which he had the kindness to send me, these beds were observed at two points, dipping in opposite directions, so as to indicate a limited basin of date earlier than the gravel-beds of that locality, which are regarded as of comparatively late postglacial date, the subjacent clay being the latest of these boulder-clays which, with Mr. Searles Wood, jun., he thinks can be distinguished in Holderness.

The shells mentioned by these authors* as found at the Hornsea-bridge station are *Limnæa*, *Planorbis*, *Bithynia*, *Anodon*, *Cyclas*, and *Pisidium*. I found traces of these loamy beds; but the cliff is now much concealed behind protective works.

The clay cliffs near Hornsea contain chalk and flint with *Belemnites mucronatus* and *B. Listeri*, Ammonites and other fossils from the Lias of Whitby, magnesian limestone from near Sunderland, coal, sandstone, and mountain-limestone from the west of Yorkshire, old red conglomerate, grauwacke, syenite with magnetic iron-ore, quartz, septariate ironstone, &c. Teeth of the mammoth likewise occur on the shore, derived from some fallen cliff.

At a short distance to the northward (marked I. in the section, Plate XVI.), the cliff is 20 feet high, and exhibits frequent alternations of gravel and clay, in a more regular order than is usually observed. Beginning at the surface, we have:—

1. Yellow and white small gravel of chalk and flint.
2. Brown clay, with very small fragments of chalk, flint, lias, magnesian lime, porphyry, &c.

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* Quart. Journ. Geol. Soc. vol. xxiv. p. 154.

3. As No. 1.
4. Layers of irony sand.
5. As Nos. 3 and 1.
6. As No. 2.
7. As Nos. 5, 3, and 1.
8. The general base of the cliff is blue clay and pebbles, among which chalk fragments are frequent—a "chalk-spotted" clay.

Hence the cliff rises gradually, and before we arrive at Atwick it has attained the height of 40 feet. Here a little gully divides the whole cliff, and crosses a freshwater deposit 100 yards in length (K, Plate XVI.). This consists of bluish and yellowish clay above, and whiter clay with shells beneath, resting on pebbly clay. Opposite Atwick is another such deposit 50 yards in length. At this place an elephant's tusk was found of extraordinary dimensions; it is preserved in the collection of Dr. Alderson, at Hull. The beacon on Skirlington Hill, the highest point of the coast between Hornsea and Skipsea, is almost 60 feet above high water. Hence it descends gradually northward; and at a height of 40 feet we observe a freshwater deposit 10 yards in length. Further on the pebbly clay sinks below the level of high water, and forms a wide hollow, in which is an extensive and interesting lacustrine deposit (L,

*General Appearance of the Peat-deposit at Skipsea.*


Shelly clays underlie the peat; but near the north end, at *, the peat touches the boulder-clay for a space.

Plate XVI. & Plate XXI.). Its length is about a quarter of a mile; its extreme elevation above high water, at the south extremity, is 12 feet, but in the middle only 4 or 5 feet. The series of depositions from fresh water is as follows:—

Peat, with roots, branches, and hazel-nuts: its utmost thickness is 7 feet; where this happens the lower 4 feet 6 inches are solid, and break like clay; the upper part is then fibrous. Yellowish clay, full of *Bithynia tentaculata, Cyclas cornea, C. lacustris*, and a few specimens of *Limnæa stagnalis*; this is seen only on the southern side of the

hollow. Blue clay, full of *Cyclades*; here is some phosphate of iron; this rests upon gravel, under which is blue or brown boulder-clay.

In this deposit an old man, who was employed in collecting gravel, accidentally discovered the head and antlers of *Cervus megaceros*, whose remains abound in the bogs of Ireland and the Isle of Man. Subsequently the lower jaw was discovered by the researches of Mr. Arthur Strickland. The antlers are a little larger than in the fine specimen in the Dublin Museum, described by Mr. Hart—measuring 11 feet 4 inches by the circuit, and 6 feet 8 inches between their tips; and there is a peculiarity in the brow-antler which I have never seen in any other specimen: it is expanded at the end, and furnished with *three* short digitations. The obliteration of the sutures of the cranium indicates the maturity of the individual, though, from the perfection of the teeth, it does not appear to have been aged. This is the second and largest specimen of the gigantic elk which has been found in Yorkshire. In the Philosophical Transactions for 1746, Mr. T. Knowlson describes and figures the head of this animal from Cowthorp, near North Deighton, Wetherby. The antlers were each 5 feet 1 inch long, and separated 6 feet 1 inch at the tips. The peat-bogs and shell-marl deposits in which the remains of this noble extinct animal have been found in Ireland, Scotland, and the Isle of Man are extremely similar to the lacustrine accumulations of Holderness, as may be seen by reference to Mr. Hart's account of the discovery of the Dublin specimen, Professor Jameson's statements respecting the Edinburgh skeleton found in the Isle of Man, and Sir C. Lyell's remarks on the shell-marl formations in Scotland.

Beyond Skipsea the cliff, composed as before of the pebbly clay, attains a height of 30 feet, but soon sinks again to an extremely low part, where, for half a mile in length, a freshwater deposit is seen, consisting of clay with shells at the bottom. Between this point and the Barmston drain the height does not exceed 20 feet, and is generally as little as 12 feet. Three deposits of freshwater clay appear in this space, and (at M, Plate XVI. & Plate XXI.) a mass of clay in undulated laminæ, which recalls the appearances under Kilnsea church. This undulated mass is

3. As No. 1.
4. Layers of iro...
5. As Nos. 3 an...
6. As No. 2.
7. As Nos. 5, 3. ...
8. The general ... ments are ...

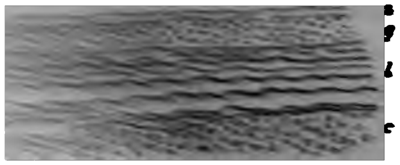
... or gravel. Beyond the Barm- ... XVI., where the cliff is 7 feet ... bottom seems almost to gra- ... The series here exhi-

... some shells. Peat. Blue clay. ... small pebbles. Diluvial pebbly

Hence the cliff ris... attained the height ... and crosses a fresh... This consists of blu... shells beneath, resting ... deposit 50 yards in ... found of extraordinary ... Dr. Alderson, at Hull. point of the coast betwe... high water. Hence it de... 40 feet we observe a fres... the pebbly clay sinks be... hollow, in which is an ...

... sand above noticed lies ... gravel. Under all is ... Dike the cliff (at P, ... of sand accumulated from ... sand and gravel, pebbly ... is composed of laminated ... clay, under a covering ... the laminated clay; but ... cliff, and continues nearly ... and the gravel rests

*General* ... and Bridlington.

Shelly clays underlie the peat; but ... clay, usually brown, with

Plate XVI. & Plate XXI. extreme elevation above ... but in the middle only 4 ... water is as follows:—

... of its ... with it.

Peat, with roots, branches, ... this happens the lower 4 feet ... then fibrous. Yellowish clay ... and a few specimens of *Limnæ*...

... the cliffs resume ... more to the ... gravel, which ... once con-

tinued to the edge of the harbour, and still are traceable as far as the artificial constructions allow. At a distance of 200 yards from these constructions laminated sandy loam appears on the cliff-top, enclosing lenticular masses of much-rolled gravel. Below is the ordinary brown boulder-clay, full of rolled stones, and some masses of considerable size, as an unrolled 2-foot block of ganister-grit containing *Stigmaria*. Mountain-limestone, chalk, hard greenish slate, red porphyry, amygdaloidal porphyry, aphanite, yellow quartz, with chlorite, jasper, flint, ironstone, Old Red Sandstone, granite, not that of Shap, were observed. Among fossils were noticed *Gryphæa incurva*, *Ammonites fibulatus*.

About 50 yards from the woodwork white shell-marls appear, and continue with a variable thickness of 1 foot to 3 inches. A thin peaty band of 7 inches then sets in and separates these marls into white above and white and grey below. Sandy gravel, 2 to 6 feet thick, succeeds and rests on boulder-clay. The marls yield *Cyclades*, *Pisidia*, *Valvatæ*, and *Limnææ*, all small, and usually below the peaty layer.

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From the preceding description of the coast of Holderness, it is evident that no formations appear there which can be considered as belonging to regular marine strata. Of the diluvial accumulations, by far the most prevalent, that which is the base of the whole cliff, is blue and brown clay containing dispersed pebbles; above this a more local deposit of undulated laminated clay; and finally, gravel on the top, or mixed with the pebbly clay. In this formation lie the teeth and tusks of the mammoth, and abundance of water-worn fossil shells, derived from neighbouring and remote districts. Resting on these diluvial beds, we find the deposits of later, more quiet, more contracted waters. Lakes, which existed in hollows of the ocean-worn surface, have been slowly filled up by clay-marl, shells, and peat, subsiding from their waters, and either drained by the industry of man, or emptied by the approaches of the sea. The shells which occur in these clay-beds belong to freshwater species now living; they lie almost invariably at the bottom of the bed of the

lake, and are covered by several feet of clay and peat *without shells*—a circumstance which seems to warrant the supposition that the upper layers of sediment and peat were produced in some short period of time, in consequence, perhaps, of land-floods.

In these deposits lie the skeletons of postdiluvian animals—the great extinct elk, the red deer, the fallow deer, and the ox, with trees and fruits which grew in the forests they frequented. In more than twenty examples on the coast south of Bridlington, it may be clearly seen that the lacustrine deposits rest upon the diluvial accumulations, but are not themselves covered by any other deposit. It is a mistake, therefore, to imagine the skeletons of deer, and the peat and trees constituting the "subterranean forest" of Holderness, to be of the preglacial era. The shells, bones, and trees belong, with a single exception, to species now in existence in this island; the deposits which enclose them are evidently the most recent in the country, and differ in no important particulars from the peat- and marl-bogs of Scotland and Ireland, whose accumulation is not yet ended.

BRIDLINGTON QUAY.—In addition to the phenomena already described in the cliffs of Holderness, we find in the harbour, and at points to the north of it, some facts not elsewhere to be observed. First, it may be noticed that in the harbour a boring was made through the drift-deposits to the Chalk, which was found at a depth of 43 feet. The Chalk was covered by 15 feet of hard conglomerate of fragments of chalk and flint, and this by 28 feet, described as clay, and assumed to be the usual brown Boulder-clay*.

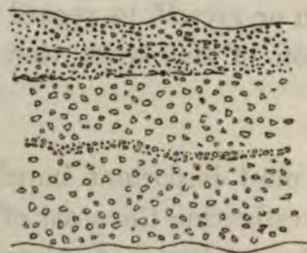
The conglomerate of chalk and flints appears on the cliffs at about one third of a mile northward from the harbour, covering the Chalk, and covered by boulder-clay. It would seem very probable that the same succession should be found in the harbour; but it is to be regretted that no proof of this has been obtained, because, for want of this information, the occurrence, a little north of the harbour, of a bed of shelly sandy clay in contact with the ordinary pebbly drift is not completely understood.

* This boring let up an artesian spring of good water which flowed and ebbed with the tide.

The part of the coast immediately north of the harbour, now occupied by pleasure-grounds and esplanades, was formerly a rude cliff, 25 feet at the highest point, dangerous to houses built upon it, and much wasted by storms. A more conspicuous building than the rest, and projecting further towards the sea, was called the "fort;" and on the shore at the foot of this small prominence, we used to find a few shells which had a fossil aspect—especially *Pholas crispata*, filled with hardened sandy mud. But it did not occur to Mr. Bean or myself to regard these as truly tertiary, and in the earliest edition of this work they are but slightly mentioned.

TERTIARY BEDS.—One of the most important inquiries that presents itself to the geologist, whilst investigating the coast of Yorkshire, relates to the occurrence of any of the tertiary beds above the Chalk; and Mr. Smith has stated, on his geological map of Yorkshire, that crag-shells occur in the neighbourhood of Patrington. These I have previously described, and cannot doubt that they belong to a more recent epoch. Professor Sedgwick, who examined the spot in 1821, describes appearances on the north side of the harbour at Bridlington, which he supposed to indicate the presence of some one of the strata above the Chalk. I have repeatedly searched, without success, for these beds; but in July, 1828, I found, sixty yards north of the harbour, below the level of half-tide, an enormous mass of dark shaly clay, whose laminæ seemed dipping to the south. It was several yards in length and breadth, was surrounded by brown pebbly clay, and contained a few fossils, amongst which were a peculiar Ammonite, the columnar joints of *Pentacrinus Briareus*, and what I believe to be a form of *Avicula inæquivalvis*. I was at first much disposed to think this a portion of a tertiary stratum, and still am altogether at a loss to explain the appearance of so enormous a mass of perishable clay, having the appearance of Lias, at such a distance from the nearest cliffs of that stratum. I recommend this point for further observation. The specimens of *Pholas crispata* washed ashore full of coherent sand prove nothing whatever on this subject: such dead shells are particularly liable to be filled with the matter on the bed of the sea; and the only remarkable circumstance in these specimens is that the matter

which they contain is unusually solidified. Excepting those imperfect indications, I have never heard of a single fact which would authorize a belief that tertiary strata exist in Yorkshire. (This was written in 1828.) We did not, however, cease to examine this part of the coast—on the 14th of April, 1833, the cliff south of the "jetty" constructed to protect the Fort; the appearances were sketched as under; I saw no shells in any of the layers.



Chalky gravel, and yellow sands.
Blue pebbly clay.
Chalk, sand, and pebbles.
Blue pebbly clay.

It was not till 1835, when the second edition of my book was printed off, that the waste of the coast laid distinctly bare, at the foot of the cliff under the "fort," the shelly sandy clays which have since acquired the title of the "Bridlington Crag."

Mr. Bean, informed of this discovery, lost no time in exploring the shelly bed; and by his and other busy hands a large series of marine exuviæ has been collected.

As the deposit will perhaps never be seen again, it is desirable to place on record the few facts which have been observed in regard to its composition and relation to the ordinary clay-drift. Mr. Bean (in a communication to the Magazine of Natural History, June 1835) makes this statement:—

"Being on a geological excursion ten days ago (from March 30) in the neighbourhood of Bridlington Quay, Mr. Walter Wilson, an intelligent lapidary of that place, directed my attention to a deposit of fragile and broken shells which the late high tides had exposed on the north side of the harbour, and near the pleasure-ground called the 'Esplanade.' Ere I visited the place, I expected to find one of the lacustrine deposits so very common on this coast. On arriving at the spot, a heterogeneous mass, only a few yards long and as many high, presented itself, composed of sand, clay, marine shells, and pebbles of every description; chalk and flint pebbles were, as might be expected, most abundant.

"In colour and appearance this shelly mass resembles the London Clay; but the

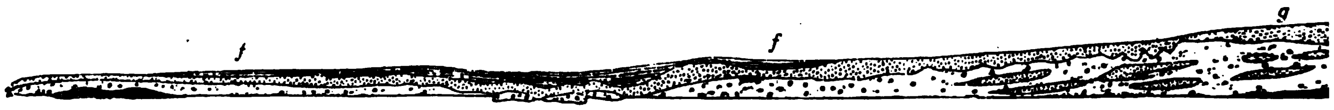
fossils bore the aspect of those found in the Crag: the shelly bed contains a greater number of species than have been at present obtained; and much caution will be requisite ere its geological relations can be truly determined. Thus much, however, is certain, that these shells are coeval with, if not of higher antiquity than the Crag."

When I reexamined the spot after this discovery, I found the shelly bed largely exposed, very irregular in its upper surface, covered by boulder-drift, and composed of dark sandy clay with small black pebbles, and chalk and flint fragments, mixed with a multitude of shells, many broken, and, except *Pholades* and *Cyprinæ*, few bivalves having their valves together. I saw no boulder-clay beneath; upwards it seemed not sharply defined from the ordinary drift without shells, but yet distinct, so as not to pass gradually into that heterogeneous mass. Allowing for the rise of the chalk northwards from the harbour, and the height of the deposit in the cliff, we may take 40 feet for the height of the upper surface of these shelly clays above the Chalk, and 25 feet for their own thickness and that of any boulder-clay or other deposit which may be conjectured to occur between it and the conglomerate.

Mr. Bean's first impression was that a large proportion of the shells belonged to extinct species; but the later researches of Mr. Searles Wood, founded on a larger series of fossils, lead to a different conclusion. The late Mr. S. Woodward found in them indications of the "glacial" climate, and concluded that the Bridlington shell-bed was of much later geological date than the Crag. My own investigations led me to adopt the view that it was a shell-bed as early as the beginning of the Glacial period (possibly preglacial), which had been disturbed and displaced bodily by the pressure which attended the boulder-deposits, and not stratified by dispersion under ordinary watery action. This may be expressed by the term *couche remaniée.*

North of the harbour, for some considerable distance, new constructions have supplanted the natural characters of the cliffs, and concealed some interesting facts of importance. Beyond the Alexandra Hotel several

freshwater deposits appear in the low cliffs to a thickness of 3 to 7 feet, and yield shells like those already named in the cliffs south of the harbour. The gravels and boulder-clay are also of the same type. The cliffs, gradually rising to 30 and 40 feet, lose entirely the freshwater bands; and the boulder-clay, besides admitting several gravel-bands, is underlain by dark laminated clay. The principal phenomena are represented in the diagram below.




*f.* Freshwater deposits with shells for considerable but interrupted spaces, north of the Alexandra Hotel.
*g.* Gravel above and enclosed in the boulder-clay (*c*), under which (at *s*) is dark laminated clay.

# CHAPTER IX.

## THE COAST FROM BRIDLINGTON TO FILEY.

No contrast can be more decided than appears between the solid, regular, continuous strata which have been formed by the repeated operations of a primeval ocean, and the mixed and irregular aggregations which mark the force and direction of subsequent water-currents on the surface of the earth. From Bridlington Pier we look southward to a long line of wasting cliffs formed of detritus swept from the distant regions of the west and north-west, and our imagination is tasked to frame conjectures on the state of the land and sea during and previous to all that violence of nature; whilst northward rise strata of chalk, which, if compared with some other formations, must be called of recent date, yet were certainly deposited and hardened, and in many places covered by several other rocks, long before any considerable part of the surface of the earth, in these regions at least, was elevated above the sea. The considerations which belong to the two classes of phenomena are, in several respects, wholly different; and many geologists of good attainments have been content to study only one of them. The superficial deposits, however, must be both closely examined and viewed on a general scale, if we desire really to unveil the natural history of the earth. For such inquiries Holderness affords one of the best examples in the British Isles.

The beds of chalk rise to the north; and as we pass along the shore, other, lower and different layers come up in succession, and expose a considerable number of fossils—amongst which we may notice sponges of many kinds commonly called *Alcyonia*, and others referred by Mr. Mantell to his genus *Ventriculites*, Echinida of the genera *Ananchytes* and *Spatangus*, *Marsupites ornatus*, and *Apiocrinus ellipticus*. The Marsupites are exceedingly abundant through a considerable thickness of the beds which appear towards the Danes' Dike; but the plates

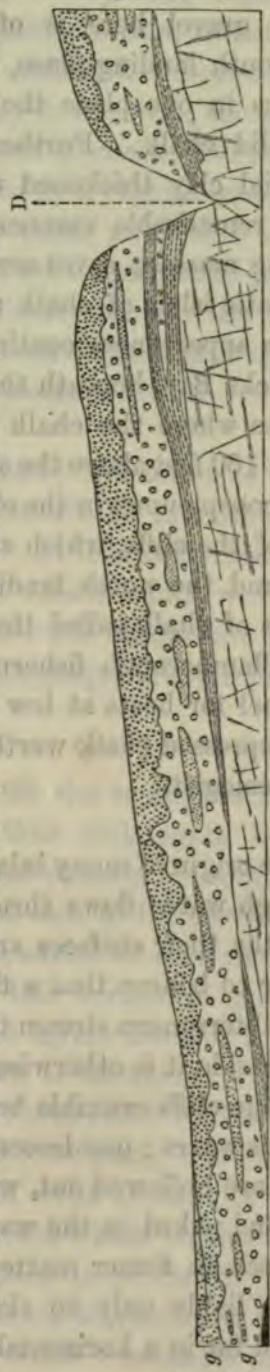
are generally scattered, owing to the decay of their connecting membranes before they were imbedded.

The Chalk makes its appearance under some peculiar circumstances. Nearly opposite the village of Sewerby the bottom of the brown pebbly clay is seen resting on a remarkable layer of what may be called chalk-rubble, 10 or 12 feet thick, composed of small fragments, which seem to have been washed together and left in a rather incoherent state. This covers the solid chalk, which rises from beneath and ascends in the cliff, which soon attains a height of 80 feet. The chalk-rubble is absent for a space of 80 yards, and then resumes its somewhat irregular place. Further on, at intervals, portions of such rubble and rolled masses of larger size, and occasional bands of unrolled fragments, compose an uncommon kind of drift. On approaching Danes' Dike this deposit becomes banded with boulder-clay and sands, grows in thickness to 12, 15, 20 feet, lies unconformed on the edges of the chalk layers, and is clearly a local drift. Very large conglomerate blocks of this drift, with aphanite and sandstone pebbles, occasionally fall from a considerable height near Danes' Dike; and from the boulder-clay which covers it, large masses of sandstone, gneiss, and aphanite are extricated by decay of the front of the cliffs, and remain for some considerable time at the foot.

The section (p. 91) represents the phenomena after my latest observations.

The Danes' Dike is an earthen rampart, running across the promontory of Flamborough from one side to the other. The southern part of this line follows the eastern side of a narrow and precipitous valley, which enters the sea between cliffs 109 feet high. At this place we obtain a clear proof of the high antiquity of some valleys in the solid strata; for here the strata of chalk are deeply excavated beneath the mass of clay and gravel and sand which was swept hither during the rush of waters at a higher level than the modern sea. It is therefore not to be doubted that such hollows are at least as old as that period. The great effects

which have been subsequently produced by the wearing of streams, the descent of rains, the course of floods, or the bursting of lakes have not always destroyed the evidence of earlier atmospheric and oceanic action. I am acquainted with several instances clearly proving that small valleys have been excavated by the streams which flow in them since the date of the glacial accumulations. But after examining the remainder of the section, and perusing the following descriptions, the reader will find no great reason to doubt that the valleys and broader hollows which reach the Yorkshire coast are generally as old at least as the glacial era, and that their principal features are due to currents of water directed, in some degree, along fractured strata and other lines of least resistance.



*s* Dark laminated shale. *c*, Boulder-clay. *r*, Chalk-rubble. *ch*. Solid chalk. *g*, Gravel above and included in the boulder-clay, and also in the chalk-rubble. D. Danes' Dike.

Beyond the Danish Dike the cliff-top continues at the same height to a little gully, which descends from the village of Flamborough; but further on it rises greatly to the beacon, which is above 190 feet from high water. This great augmentation of height is not owing to any sudden change of dip in the Chalk, but to an uncommon abundance of the diluvial matter which covers it. Around the beacon are several large boulders of granite, greenstone, fine-grained sandstone, &c., not less than three quarters of a ton in weight. Much chalk-rubble is mixed with the diluvium of these cliffs. Descending by a rapid slope to the south landing-place of the Flamborough fishing-boats, we observe here, as at Danes' Dike, the chalk strata deeply excavated beneath

a thick cover of chalk-rubble and diluvial clay. The chalk-rubble and other gravel here is often agglutinated into solid blocks. Beyond the south landing-place, the cliff, gradually bending round to the west, attains in one place the height of 136 feet, and is mostly composed of solid chalk. Further on, where the chalk is depressed and the diluvial clay thickened upon it, the cliffs are wasted by the sea in a very remarkable manner: broad and lofty arches appear in the projecting masses; caves are formed which open upwards to the day; and romantic islets of chalk are surrounded by the full swell of the waves. These appearances continue from the first pillar, called the Matron, to Selwicks Bay, beneath the light-house; and the cliffs are decidedly most broken where the chalk is least elevated. The light-house appears to stand 160 feet above the sea. Beyond Selwicks Bay layers of flint become very conspicuous in the chalk, and several curious indentations break the line of the cliffs, which are from 130 to 140 feet high between Selwicks Bay and the north landing-place, in one of which rise two island pinnacles of chalk called the King and Queen. The north landing-place of the Flamborough fishermen is a little hollow or bay of rocks, with a channel for boats at low water and a gravelly beach. Here are caves in the depressed chalk worthy of examination by the lover of scenery and the geologist.

The origin of many inland caverns in limestone is exceedingly obscure. Though water flows through many of them, and by incessant attrition smooths their surfaces and modifies their forms, yet, perhaps, we ought rather to believe that a fissure previously existing directed the course of the subterranean stream than that water scooped out the whole cavity. By the seaside it is otherwise; the destructive action of the sea is not doubtful: the cliffs crumble before its salt vapours, and waste away under its furious waves; one loosened stone beats down another; and thus the soft parts are hollowed out, whilst the harder portions jut into promontories or stand naked in the water. If the soft parts exposed to the waves be enclosed in firmer matter, caves and arches are formed, which are afterwards liable only to slow alteration; but if these yielding materials extend far in a horizontal direction, the cliff undergoes rapid diminution.

These observations are of general application. Projecting capes and headlands are usually composed of firmly compacted strata, whilst bays and estuaries commonly present less-resisting materials. Between the north landing-place and a more remarkable bay to the west, the prominent cliffs are 117 feet high, and mostly composed of chalk; but at both these bays that stratum sinks low, and is covered by a vast accumulation of diluvium, whose unsolid materials fall and waste away into slopes, which often become covered with grass, and afford a dangerous pasture for cattle and sheep. But on the west side of the remarkable bay before alluded to, the diluvium is subject to such continual waste that it appears in the form of bare pinnacles resting upon the caverned chalk.

The formation of these sea-shore caves is aided by the action of rains, which descend into fissures of the chalk, and contribute to weaken the upper part, while the sea wastes the lower part. At length the roof falls in; the cave becomes a sea-beaten cleft between walls of chalk, which are often cut across by the waves; and then pinnacles and needles are left as memorials of what was solid land, "rudera longinqui sensim præterlapsi ævi."

From the last-mentioned point the chalk cliffs rise rapidly to Danes' Dike, which is 292 feet above high water, then sink again by the Summer-house to a point which displays the most remarkable contortion of the strata known on this coast. As may be seen in the section, the chalk-layers are here bent in sigmoidal flexures, whilst on each side they are perfectly horizontal. On the eastern side this horizontal direction changes to a rising arch, from which again the layers descend in long perpendiculars, to join the depressed arch which is connected with the horizontal layers on the western side. This remarkable confusion of declination occupies the whole height of the cliff (240 feet); but its horizontal length is small. I could not determine what amount of dislocation is occasioned between the horizontal strata which enclose these contortions, nor, indeed, whether any such effect is produced. It is scarcely possible to conceive how such flexures could be produced, except when the strata were soft and yielding; and it seems reasonable to sup-

pose that they are nearly coeval with the deposition of the Chalk. As in many other instances, the diluvial matter lies without any distinction or peculiarity upon both the regular and the disturbed strata.

About a mile further is the highest point of the "white cliffs;" and here, at an elevation of 436 feet, a beacon, I believe, once stood on the very brink of the precipice. A considerable part of this surpassing altitude is owing to an unusual thickness of diluvium which here covers the chalk. The views from this station are very extensive; a long line of coast divides the area into two semicircles of land and water: one half the horizon is sea; and the remainder stretches from the heights above Robin Hood's Bay across the moorlands to the oolitic hills, and then pursues the southward sweep of the wolds till hills and plains are mingled in the distance. We then descend for about a mile to the last of the white cliffs, 382 feet high. The range of chalk here quits the sea-coast, and proceeds inland by Speeton beacon, 450 feet, above Hunmanby, and along the south side of the Vale of Pickering, rising higher and higher towards the west, till it attains its extreme height near Garraby beacon, 805 feet above the sea. From its last high precipice the chalk descends along the shore by an irregular broken escarpment covered with diluvium; and at length its lowest layers are seen. These are always characterized by an admixture of red chalk containing the very peculiar Belemnite which Dr. Lister noticed so long ago as occurring *semper in terrâ rubrâ ferrugineâ* *. *Serpulæ*, small *Inocerami*, and *Terebratulæ* have been found in this red chalk.

In my first surveys of this coast the red chalk was exhibited very irregularly, except in a little ravine which almost exactly separates the chalk from the blue clay of the Speeton cliffs. But on several later visits I found the base of the cliffs considerably to the southward clearly exposed; and there several tinted bands appeared, the lowest being those which were formerly noticed in the ravine alluded to. Mr. Wiltshire

* For want of examining the localities which he indicates, geologists have often given the name *Belemnites Listeri* to a very different species (Smith, Strata ident. Brickearth, figs. 4 & 5), and assigned Lister's fossil to the Gault.

and others have published notes of their observations; and I am indebted to the pencil of a lady for a very good sketch of the general range of the cliffs and slipped ground in which the red chalk is to be seen.

At the foot of a high cliff about half a mile south of the ravine before spoken of, the following section was observed (recorded September 1855 and April 1866), showing considerable thickness of red and pale lumpy beds below the Chalk with flints, and some streaks of red tint included in the lower part of that calcareous mass:—

| | | |
|---|---|---|
| Lower part of the White Chalk, with flint layers | Fossils very rare in all this part of the Section (*Inoceramus*). | |
| Lower Chalk, without flints of grey or yellow tint | | |
| Upper Red bed | 3 feet. | Fossiliferous. |
| Chalk and marl in thin bands | 36 „ | Few fossils (*Inoceramus*). |
| Chalk more solid | | |
| Red band, irregular | 0 to 2 feet, sometimes a mere stain. | |
| Soft chalk, with marl partings of yellow and grey tint &c. | 10 feet. | *Terebratula.* |
| Red, with pale bands | 7 „ | Fossils. |
| Red lumpy chalk | 7 „ | Fossils. |
| Grey lumpy chalk, with marly partings | 15 „ | Fossils. |
| Red uniform chalk | 12 „ | *Belemnites Listeri.* |
| Red lumpy chalk | | |
| | Bottom not seen. | |

Proceeding northward to the little ravine, we find in its channel and along the banks the red chalk bands well exhibited, but for very limited spaces. These represent the same beds as those already described under the high Speeton cliff, but with some variation. The strata are disturbed, and dip in some places 60°, 70°, 80° to the southward, under what seems

like a slipped cliff of white chalk. There is a pale flush of red in this chalk about 40 feet above a series of grey nodular beds (4 feet), red nodular beds (3 feet), grey nodular beds (2 feet), red and grey beds (4 feet), more solid red beds (4 feet). There appears to be another set of undulated and nodular red beds 4 feet thick, dipping 80° south; they are in the stream, and are in contact (in a soft state) with the subjacent blue clay of Speeton; but there appears no real gradation between the deposits, though there is some appearance of parallelism to a nearly vertical plane on the north side of the ravine.

The description as given by Mr. Wiltshire (Mem. Pal. Soc. for 1862) agrees in general with the preceding section, with some differences as to the estimated thickness of beds, and in particular a much greater thickness of the lowest group of red beds. Those which in my notice are 12 feet thick (the bottom not seen), are stated to be more than 30 feet thick, "the lower beds becoming nodular and of a bluish cast, thus graduating into the Speeton clay below." These Lower Red beds are regarded as equivalents of the Red Chalk of Norfolk, or "Hunstanton Limestone." The Upper Red bands occur in the Chalk in the railway-cutting above Market Weighton; and the lower bands accompany that deposit, as Lister said, everywhere "as you climb the woolds from Speeton to Spilsby."

To complete our description of the chalk cliffs, we may notice that the chalk-rubble, which so uniformly covers the stratum on the south side of Flamborough Head, is hardly ever seen on the north side. Caves abound in the northern cliff, which are exposed to the full rush of the sea; but not on the southern side, where the water is more calm. Organic remains are very abundant in the upper part of the stratum between Bridlington and the south landing-place; but the lower and harder chalk contains hardly any other fossil than the *Inocerami*. Upon the whole the Chalk of Yorkshire is comparatively poor in fossils. About forty species only were found in it previously to 1829, while thrice that number had rewarded the collectors in Norfolk, Wiltshire, Sussex, and Kent.

## CLIFFS OPPOSITE THE VALE OF PICKERING.

From the termination of the white cliffs the coast bends to the northward, and exhibits in succession, rising from beneath the Chalk, the Speeton clay, the Kimmeridge Clay, and the Coralline Oolite series. The Speeton clay shows itself immediately in contact with the red chalk, so that there can be no question of its being the next subjacent stratum; and therefore it will be useless to look for the Greensand formation in this part of Yorkshire. The sand represented on Smith's map of Yorkshire as ranging on the south side of the Vale of Pickering is merely superficial: blue clay is found at too many points in contact with the bottom of the chalk to leave the slightest doubt on the subject. At Speeton the clay is dark and laminated, with distant layers of nodules of argillaceous ironstone, the larger of which are fissured within, and have these fissures either empty, lined with crystals of selenite and iron pyrites, or filled up with calcareous spar. Such large nodules occasionally contain Ammonites and fragments of Hamites. The smaller oval nodules frequently enclose small crustaceous animals having the general appearance of the genus *Astacus*, but with attenuated fore legs and slender subabdominal processes (*Meyeria ornata*). A great number of very interesting fossils, which will be described hereafter, have at different times been found in the clay at Speeton. Among the most curious are a fragment of a jaw of *Gyrodus* containing four rows of teeth *in situ* (in the possession of its discoverer, Mr. Preston, of Flasby), teeth and vertebræ of Saurian animals, many beautiful Ammonites, Hamites, and Nuculæ (which ornament the cabinets of Mr. Bean and Mr. Williamson). To make any tolerable collection of the beautiful fossils of Speeton requires patience and assiduity; for, though they are really not scarce, yet it is only after rains have exposed a fresh surface that they can be found in plenty. Many of the nodules are phosphatized.

Several remarkable fossils which Mr. Mantell described from the Gault of Sussex are found at Speeton; and generally a great analogy may be perceived between the fossils of the blue clay of Speeton and Knapton, and those which belong to the argillaceous beds which lie beneath the

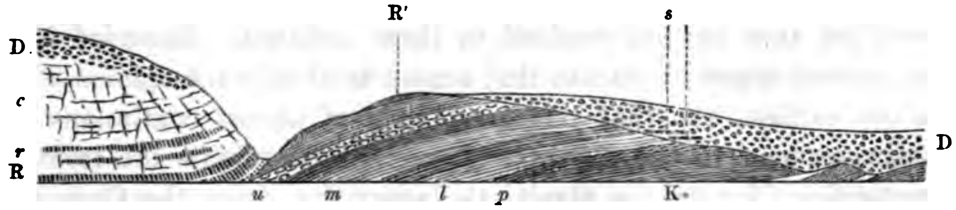
Chalk in Kent and Sussex. But some of the Speeton fossils bear so great a resemblance to those of the Kimmeridge Clay, that Professor Sedgwick has been led to refer them to that stratum. The evidence on this subject may be more completely unfolded in the chapter devoted to organic remains; but in the mean time I may state that my observations lead me to refer at least the upper part of the Speeton clay to the Gault of Cambridge and Sussex; and I have before said that the lower argillaceous range along the north side of the Vale of Pickering belongs to the Kimmeridge Clay.

Like the Chalk under which it sinks, the Speeton clay dips southward. It is exposed in the broken cliff to an elevation of 200 feet; and I had once (1826), in a particular condition of the tides, an opportunity of seeing some harder beds than common, with compressed Ammonites at low-water mark. Some remarkable contortions of the clay, which appear on the shore towards its northern termination, are represented in one of the detached sections (Plate XXII.). It is covered, even where highest, by a great quantity of diluvial clay and pebbles; and as we proceed northward, it sinks continually, and in less than a mile from its first appearance is lost below the level of the sea.

Since the preceding description of the Speeton coast and cliffs was written (in 1828), the relation of the great Clay series there exhibited to the Gault has been more fully explored; and the opinion has been formed, both by English and foreign geologists, that a great analogy on the whole exists between the Speeton clay and the Neocomian strata of the Continent. For the most patient investigation of this subject we are indebted to Mr. Judd, who not only adopts the opinion referred to, but further admits in the section a representative of the Portland Sands above the Kimmeridge Clay.

In September 1855 I devoted much time and attention to the difficult task of subdividing the thick Speeton clay into upper, middle, and lower parts, and endeavoured to assign to each zone of the clay the most characteristic fossils. In 1866, 1870, and 1872, the same purpose has been followed. In the course of these examinations some facts of consider-

able importance have been observed in regard to shell-beds associated with the drift which covers the Clay.




D. Drift-clay and boulders. *s.* Shell-bed in or under the drift. *c.* Chalk, white. *r.* Small red bands in the Chalk. R. Principal red and grey beds. R'. Detached part of the red beds. *u.* Upper part of Speeton Clay. *m.* Middle part of Speeton Clay. *l.* Lower part of Speeton Clay. *p.* Thin Portland bands. K. Kimmeridge Clay.

In the above diagram the principal facts, as they appeared to me, are represented; and they are in general agreement with the conclusions of Mr. Judd, which, however, include some points of detail which it is next to impossible in the present state of the slipped and ruinous cliffs to reexamine with confidence. The main facts, however, may still, with some difficulty, be verified; and future storms may clear away some of the confused and displaced masses.

Instructed by Mr. Judd's researches*, and contracting the data as observed by myself into three principal groups, the Speeton clay (limited above by red and grey chalk, and below by the pebbly bands which rest on Kimmeridge Clay) may be thus represented in a vertical section. The total thickness assumed is 350 feet; but on Mr. Judd's estimate it would be 500 feet:—

| | |
|---|---|
| Upper Division (100 feet) (Upper Neocomian) . | Dark laminated clays, with very few fossils. Pale laminated clays with septariate nodules used for cement. *Vermicularia Sowerbii* occurs here in plenty, Ammonites rarely. These beds, once well exposed, are now difficult to explore. |
| Middle Division (150 feet) (Middle and part of Lower Neocomian) . | Blue clays with scattered nodules containing *Meyeria ornata*, *Ancyloceras* (large), *Belemnites jaculum*, *Exogyra sinuata*, *Nuculæ*, *Terebratula*. |
| Lower Div. (100 ft.) (part of Lower Neocomian) | Blue clays with many Ammonites—*Belmnites lateralis*, *Ancyloceras*, *Exogyra sinuata*. |

* Proceedings of the Geological Society, January 22, 1868.

Through all but the higher part of the mass, with some differences of form, *Exogyra sinuata* is certainly traceable; Ammonites appear in zones. *Belemnites jaculum* haunts the middle division, and *B. lateralis* the lower; but they are not confined to these divisions. Regarded in its most general aspect, I do not find reason to change the opinion which was the earliest, viz. that this great body of almost continuous clay contains evidence of the sequence of marine invertebrate life from the Kimmeridge Clay to the Gault, the separation from the Cretaceous system being marked by some appearance of unconformity and great change of local physical conditions. What in England is called "Lower Greensand" is partly a littoral deposit (Potton, Faringdon, Hunstanton), and may readily be admitted to have its pelagic equivalent in some part of the Speeton clay where *Exogyra sinuata* occurs. That fossil extends through nearly the whole of the clay (not to the dark upper beds, however); and one looks out for *Ammonites lautus*, *A. dentatus*, and other fossils of the Folkstone Gault; but they have not been seen as yet at Speeton. *Belemnites minimus*, however (not the true *B. Listeri*), is admitted by Mr. Judd in the upper part of the Speeton clay.

While searching these cliffs in the autumn of 1855, I discovered a considerable bed of shelly sands under or in the lower part of the drift at

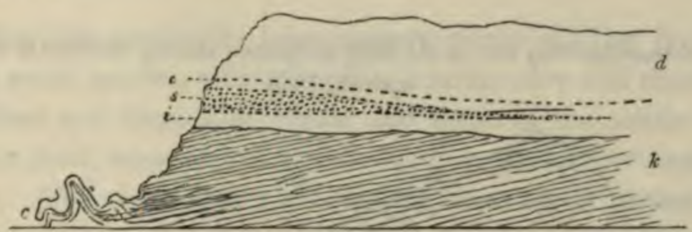

*d.* Drift, of usual appearance. *c.* Chalk fragments. *s.* Shell-bed. *i.* Interval not well seen. *k.* Kimmeridge Clay. 1855.

a considerable height above the shore, and took measures and bearings to recover the spot. The shells then found were all Dimyaria (*Cardia*, *Tellinæ*, *Amphidesma Listeri*, *Mactræ*, *Psammobia*), shells of a sandy

shore; they were often found with valves united. Only living species were found, unless a very large *Cardium*, much resembling *C. Parkinsoni* of the Crag, were really of that species. This shell-bed, reexamined in 1872 by Mr. J. E. Lee and myself, yielded the same shells and a portion of *Cyprina islandica*, and a *Littorina* with colour-bands preserved.

The situation is nearly over the contorted pebble-beds, at a height of 105 feet from the shore, the drift rising here to 160 feet. The shelly sands are seen to be covered by a clay-drift with chalk fragments in unusual abundance immediately over the sands. These are 10 feet thick; they are traced downwards to within some 8 feet of the Kimmeridge Clay; but this junction has not been actually seen, and it is supposed that a small band of drift-clay may underlie the shells. It is obviously a portion of the old sea-bed, and may be compared to the so-called Crag at Bridlington and the shell-bed found by Sir C. Lyell at the base of Dimlington Cliff.

I subjoin a second drawing, with the situation of the contorted beds added, 1872:—




About forty years since Mr. Bean showed me some of these shells; and I was struck by the resemblance to Crag, both of the shells and the yellow sandy matrix; but my friend, supposing them to have been collected by birds, did not inform me of the locality, and appears not to have made further research. This is, I believe, the only notice which has been published, though soon after my examination in 1855 a communication on the subject was made to the Ashmolean Society at Oxford. Though, as I believe, only one bed of these shells occurs, the slipping of the cliffs has made a kind of double escarpment, so that when first seen, in 1855, there was a large exposure; and but for other occupations

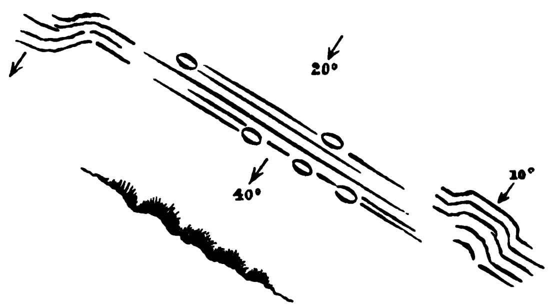
measures would have been taken to excavate largely, and obtain a more complete description of the deposit.

PORTLANDIAN BEDS.—The Speeton clays rest on a single or double bed of pyritic pebbles and phosphatized nodules, fragments of Belemnites and other fossils, which, with some dark shales and harder layers below, are referred by Mr. Judd to the Portland group of strata. He notices among the few fossils *Ammonites gigas* and *Lucina portlandica.*

KIMMERIDGE CLAY.—The shales under the pebble-bed have been always regarded by me as belonging to the Kimmeridge Clay; they contain ammonitiferous layers like those to be immediately noticed, a few hundred yards north of the contorted beds.

On favourable occasions, at low water of spring tides, one may here walk 100 yards and more on firm laminated dark shales with septaria—the shales being full of Ammonites and many white shells of the Kim-

*Plan of the Kimmeridge-Clay beds on the Shore at Speeton, showing the edges of the laminæ with septaria,* 1855.




meridge Clay, which may be almost exactly matched in the clay-pits of Shotover Hill and the railway- and canal-cuttings near Swindon. Among these are fine-ribbed Ammonites like *Ammonites Hector*, the coarse-ribbed *A. biplex*, *Discina Humphreysiana*, *Lingula ovalis*, *Thracia depressa*, *Ostrea*, *Avicula*—shells which in the Midland Counties belong to

a part of the Kimmeridge Clay not far below the sandy cap of that stratum.

These beds are in a position indicating considerable local disturbance, the axis of which ranges N. 55° W.; but this is subject to twist, both in the northward and southward parts.

The dip is mainly to the S. 35° W., and varies from 10° to 40° in the course of 100 yards. I suppose these beds to be 100 feet deep in the Kimmeridge deposit.

Thus indications of disturbance of the strata are traced for a considerable breadth (more than a mile) from the disappearance of the red chalk.

Other and lower beds of the Kimmeridge Clay, with *Aptychus*, *Ammonites*, and some peculiar small Belemnites, make slight appearances at several detached points in and under the drift as we proceed northward toward Filey; but nowhere have we seen on this coast the lowest beds (which usually contain *Ostrea deltoidea*), though they have been noticed about Kirkby Misperton and other places near Helmsley, as well as at Ellougton near Cave.

The cliffs which occupy the long concave sweep of Filey Bay, are much broken by small gullies, which exhibit boulder-clay and short bands of gravel. Here and there Lias fossils and spoils of the oolitic moorlands occur in the drift, especially *Gryphæa incurva*, *Ammonites communis*, and *Leda ovum*. The coast, feebly guarded by these easily wasted materials, rarely rises to 100 feet in height (terrace at Filey); and nowhere between Hunmanby and Filey does the inland surface reach 200 feet. In fact between Filey and Murton the watershed between the sea and the Vale of Pickering does not much exceed 100 feet above high water; while between the sea and the broad and extended surface of that vale, often covered by inundations, the difference of level is less. Were a channel cut through the drift, the outflow from that vale might be directed to the eastward, the floods be carried off, and a new harbour formed in place of the ευλιμενος κολπος, or Portus Felix, which some believe to have given birth and name to Filey.

On approaching Filey from the south, we observe on the cliff-top,

78 feet above high water, a small lacustrine deposit, which occupies about one quarter of an acre. It consists of light-blue clay, peaty clay, blue clay, white clay and peat, altogether 4 feet thick, upon sand and gravel.

It deserves remark that the diluvial clay north of Flamborough Head is decidedly of a redder colour than that which is found in Holderness. This circumstance is very evident in Filey Bay, where the cliffs afford few other subjects of observation, till at the northern promontory the oolitic rocks emerge from the sea and form the long reef called Filey Brig.

*Note on* p. 99.—The expectation of the rich mine of Speeton fossils being reopened by nature, expressed in this page, has been already in part fulfilled. On a recent visit to the coast, for the purpose of repeating some observations and measurements, I found that the storms of the early part of 1873 had so far exposed the unmoved clays, that Mr. Cullen had been able to obtain good specimens of large Crioceratites and other well-known fossils which have been desiderata for years. (June 18, 1873.)

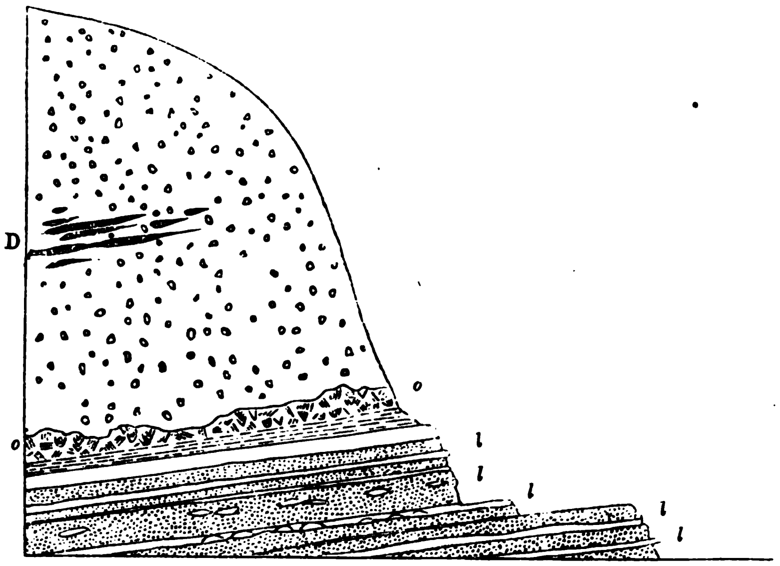
# CHAPTER X.

## CLIFFS FROM FILEY TO SCARBOROUGH.

THAT at some former period the rocks which emerge from beneath the Vale of Pickering, in strata sloping to the south, but precipitous toward the north, have had their surfaces exposed to the ravages of water, is evident by inspecting the cliff above Filey Brig; for here the diluvial clay, rising to the height of 106 feet, rests upon the lower beds of Coralline Oolite, which immediately cover the calcareous grit. The upper portion of the oolite and the upper calcareous grit above it, which occur *in situ* a few miles inland, had been removed before the diluvial matter was laid upon the wasted surface of the remaining rocks.

In the enlarged section of these appearances, presented below, it

*Filey Promontory.*

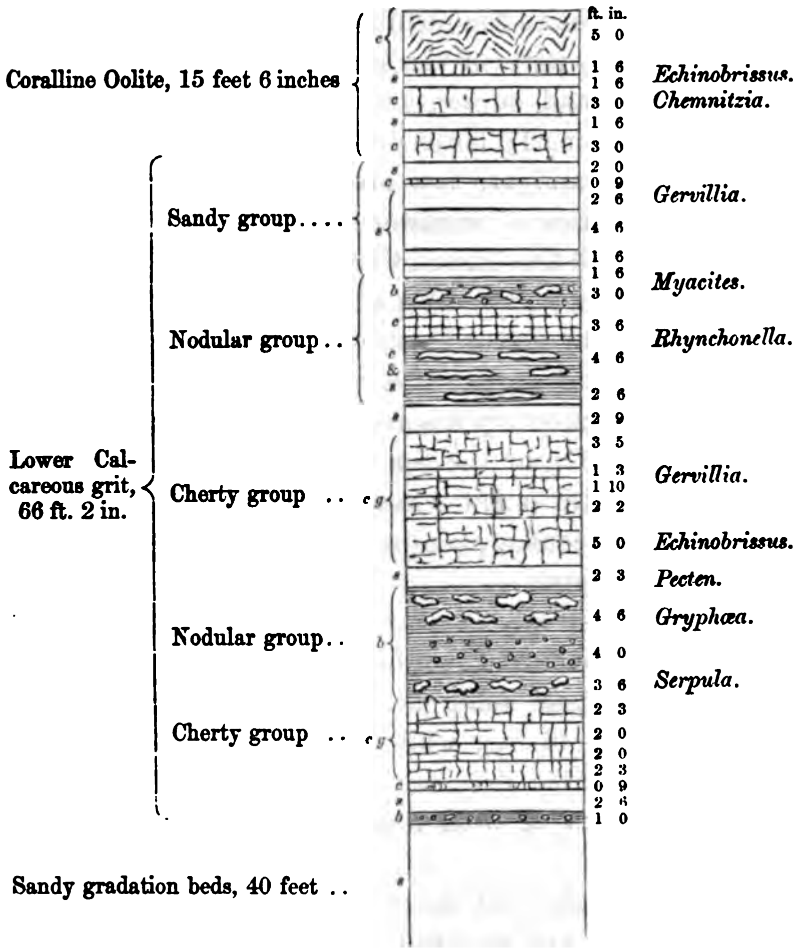



D. Drift, including sandy layers. *o.* Shaken oolite. *l.* Beds of limestone, partly oolitic.

will be seen that the diluvium rests on Oolite, 5 feet in thickness, of which the upper parts are shaken and displaced (*o*); beneath are two beds of solid oolitic limestone (*l*), separated by soft, yellow, calcareous grit, which contain *Echinobrissi*, *Myacitæ*, *Trigonia costata* and *T. clavellata*, *Pecten viminalis*, *Pecten vagans*, *Gryphææ*, *Chemnitziæ*, &c. These beds may be included in the Coralline Oolite, while the beds below, in which yellow sandy layers prevail, may be classed with the calcareous grit, of which beds to the thickness of 80 feet rise from the sea, within the distance of a quarter of a mile. In the upper and middle parts of the rock lie a few alternations of limestone; and both these and the grit-beds contain most of the fossils which occur in the oolitic layers above. The surfaces of the beds of calcareous grit are singularly characterized by ramified masses of doubtful origin, which appear like dichotomous cylindrical sponges. Several of the yellow sandy beds contain large spheroidal, highly indurated, often shelly, calcareo-siliceous balls. These bands of sandstone and hard balls may be traced for a great distance along the perpendicular face of the rocks, from Filey Brig, under a cover of "diluvial" clay and pebbles, to the summit of Gristhorpe Cliff.

Surface of Root-beds.

After often-repeated measurements of the numerous beds of different composition exposed in the Brig, and the cliffs north of it, the following general section was drawn in 1872:—




For distinction, calcareous beds (*c*) and cherty beds (*cg*) are marked by vertical joint-lines, and ball beds (*b*) have included spheroidal or irregular masses; sandy beds are left blank. The division-line between the Coralline Oolite and the calcareous grit is almost arbitrary. The sandy gradations below make a natural passage to the Oxford Clay. Scale 20 feet to 1 inch.

The beds, mostly yellow in the sea-beaten cliffs, would probably be found of a pale blue at a considerable depth underground; and in fact such a tint is often observed in the central and unaltered parts of large blocks. In most of them the root-like parts abound, in others irregular ramifications and nodules, and in some of them balls, all more calcareous than the remainder of the bed. The balls are often formed by aggregation round many shells, or round some one Nautilus or Ammonite. Some of these are spheroidal, others irregular and almost ramose in

figure, so as to make a transition to the nodular and undulated limestone beds which appear in different parts of the section. In the upper parts these are wholly calcareous and oolitic, and the yellow beds are frequently in the state of oolitic marl; lower down in the section the limestones are gritty or cherty, and are less and less abundant till they wholly vanish in the thick series of sandstones, which grow gradually more and more argillaceous till the Oxford Clay is reached.

Solid as appear these rocks at the base of the Filey cliffs, it needs but a few years to prove a rate of sensible decay, and a few hundreds of years to give some measure of great waste. The last poor vestige of Roman occupation on the promontory was removed a few years ago from the dangerous edge of the cliff near the Spa—one square hovel full of bones and broken pottery, with a few coins and other objects thrown aside by the inhabitants of some villa, perhaps the summer resort of some rich colonist or legionary quæstor.

The cliffs below the Spa are deeply excavated into picturesque "baths" along the line of the yellow sands and ball-beds; deep fissures in these rocks admit the forceful sea and suffer heavy bombardment with the loosened balls and tumbling blocks, while rain-water entering from above contributes to weaken the defence. It requires no prophet to foretell the coming breakdown of what remains of the promontory of Filey.

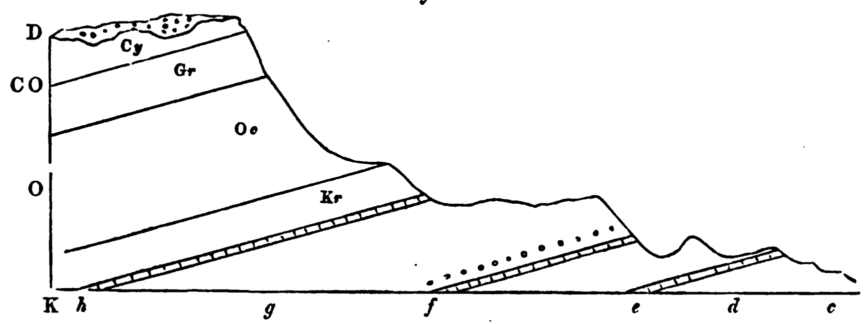
It is fortunate for the geologist that the strata here indicated make so considerable an appearance in and near to the Brig, in accessible situations; for as we proceed to the northward the cliffs become quite inaccessible over deep water. The beds may be well followed, however, by the eye, and slightly examined on the cliff-top at intervals, between the Brig and the highest part of Gristhorpe Cliff—the ball-beds, cherty beds below, sandy beds and shales, till these last change gradually to the true Oxford Clay. This clay appears in the cliffs about three quarters of a mile north of the Brig; and soon afterwards the sandy and irony Kelloway rock and the shelly and calcareous beds called Cornbrash rise from the sea and take their place in the cliffs, of which the highest shelf is 280 feet above high water.

In Gristhorpe Cliff and Red Cliff the gradations by which the lower part of the calcareous grit passes to the Oxford Clay are very conspicuous, but not in general accessible to minute research, nor is the Oxford Clay favourably situated for special examination. The Kelloway rock is found to be oolitic at the top, with the grains mostly ferruginous; it is, in fact, though imperfect, the base of what might elsewhere be capped by an earlier type of the Middle or Oxford oolite. The mass of the rock below (20 feet) is solid; the lower part (12 feet) is softer, and passes to a blue shale bed, which is from 5 to 12 feet thick, and contains *Glyphia* and *Hemipedina*. This may be regarded as the lowest known member of the "Oxfordian" beds in the north of England.

The strata now to be noticed, corresponding in their whole scope to the Lower or Bath oolites, present, as already observed, very marked differences from, but also real affinities with, those rocks as they are seen in the south of England. They vary at almost every step by often sudden changes in the thickness and quality of the sandstones and shales, which predominate over the calcareous shelly strata. These latter, accumulated around marine shells, have the character of regular courses; the former, of estuarine deposition, manifest the local irregularities due to unstable and temporary currents, and show, by their thickenings and attenuations, by peculiarities of structure and drifted contents, the influence of variable currents from the land. In these somewhat irregular deposits, one or two examples occur of marsh-living plants *in situ* and even attitude of growth, and a few freshwater bivalves in the place of their abode. Partially tranquil fresh water, possibly a temporary lake, is thus indicated, especially in that part of the section where thin layers of coal occur from 20 to 40 feet above the oolitic limestone with *Cricopora*, which gives a sure zero-line for the measures of thickness in the Gristhorpe cliffs. It is at least certain, not only that a large area has here received alternately sediments from the sea and drifts from the land, but that parts of this area have been covered alternately by tranquil sea and quiet fresh water. There has been, in the course of oolitic time, a general depression of the sea-bed; but it was interrupted at several epochs and for considerable

periods, during which large quantities of river sediments were spread over the marine strata till a further depression of the region brought again another series of sea deposits. The following general section may serve as an index to the descriptions which follow as far as Cloughton:—

*Section of the Cliff at Gristhorpe, from the Calcareous Grit to beds below the "Millepore Rock" of Oolite.*




The series of deposits between the Cornbrash and the shelly beds of the Bath oolite, nowhere else so well seen on this coast, has been measured and remeasured by myself at Gristhorpe, partly in descending the cliff, by a path now washed away, and partly on the shore*. Allowing for great variation in the sandstones and shales, this "Upper Carbonaceous Series," which appears to be entirely of estuarine origin, may be expressed in the following terms, the whole thickness being, on an average, about 100 feet:—

* Dr. Wright has given a general view of this section in the 'Proceedings of the Geological Society' for 1859.

| | ft. in. | |
|---|---|---|
| CORNBRASH LIMESTONE ...... | 2 0. | |
| | 5 0. | Shale, with root-masses. |
| | 1 6. | Dark shale. |
| Skerry sandstone .......... | 0 10. | |
| | 3 0 to 6 ft. 6 in. | Pale shale. |
| Skerry sandstone .......... | 1 10 to 4 ft. 6 in. | |
| | 14 0. | Pale shale, carbonaceous at the bottom. |
| Sandstone, pipy .......... | 1 6. | |
| Sandstone, laminated ......{ | 1 6. | |
| | 1 6. | |
| | 6 0. | Dark shale, carbonaceous at the bottom. |
| Laminated white sandstone and pale blue shale, with some jet .............. | 8 0. | |
| | 9 0. | Pale clay, purplish in the middle. |
| GRANULAR IRONSTONE (interspersed) .............. | 29 6. | Pale and purple clays, with thin sandstones and interspersions of granular iron &c. |
| Variable grits and shales.... | 8 0. | |
| GRANULAR IRONSTONE ...... | | |
| Variable grits and shales.... | 12 0 to 20 ft. | |
| | 4 0. | Clay jet, ironstone. |

GREY LIMESTONE SERIES.

In this section the Cornbrash is in a very reduced condition, often only 2 feet thick. The uppermost shelly part contains *Terebratula lagenalis*, *Tancredia*; then follows a band of *Ostrea Marshii*, and at the base is a blue sandy bed marked by black hard ramifications, supposed to be of fucoidal origin.

A somewhat different section appears in a watercourse which divides the bold scar-edges of Newtondale, near Saltergate Inn. Here we have in descending order:—

Kelloway Rock in considerable thickness, with hard and soft parts; the top stone in great blocks, good for building.

Clay or shale, 10 or 12 feet.

(*h*) Cornbrash, in beds about 2 feet thick, partially ferruginous, to the extent of 10 or even 20 per cent.

Calcareous, nodular, ferruginous shelly bed.
Sandy, calcareous, hard bed.
Sandy and indurated layers.
Sandy, with iron band in the middle.
Sandy bed.

(*g*) Shales and sandstones of various tints, thickness, and hardness.
Shales and sandstones with two bands of ironstone-balls and layers of plants, as at Scalby; the lowest band of ironstone granular or pisolitic, corresponding with that noticed at Gristhorpe. It is a rich bed, and was computed to yield 2500 tons in an acre.
White carbonaceous grits below.

The shore and cliffs of Gristhorpe Bay, and the coast immediately to the north of it, exhibit the whole series of rocks from Cornbrash to the Millepore oolite, in a complete and continuous section, of which the general meaning is perfectly clear, though almost every bed between the Cornbrash and the oolite just named is variable, the sandstones remarkably so. Though visible for a long range as they rise successively from the sea-level, much patience is required in tracing them along the cliffs. Formerly a considerable portion of these beds was apparent in a picturesque island rock, which marked the north end of Gristhorpe Bay; only the thick sandstone base now remains. (See Plate XXII. for a general representation of the appearances in 1828.)

From this point the coast turns northward again; and the strata are all measurable in favourable states of tide, down to a remarkable oolitic rock rich in Millepora, Echinida, &c., and some sandstone beds below.

Since my first publication in 1829, the succession of beds at this interesting place has been the subject of frequent scrutiny by many good observers, as Professor Williamson, Professor Morris, Dr. Wright, Dr. Lycett, Mr. Leckenby, and Mr. Judd. I have thrice measured or carefully estimated every bed, once aided by Mr. Peter Cullen, and lately by one of my earliest fellowworkers on this coast, Mr. John E. Lee. The following summary may be compared with my original section (drawn up in more general terms in 1828), the series as given by Professor Williamson (first in a private letter to myself, Oct. 1835, and afterwards in a communication to the Transactions of the Geological Society, vol. v. p. 233), and Dr. Wright's account of the same beds (read to the Geological Society in 1859).

Section of the series of subcalcareous and ferruginous beds, some of them yielding marine shells, in Gristhorpe Bay, south of the island:—

| | | ft. | in. |
|---|---|---|---|
| Fossiliferous beds (*f*), 15 ft. 3 in. | Hard sandy bed, irony at top, with decomposing bisulphuret of iron and some jet | 1 | 3 |
| | Grey streaky sandstone, with some decomposing bisulphuret | 2 | 0 |
| | Brown laminated, partly ferruginous, bed | 2 | 0 |
| | Grey sandy shales, sulphurous | 2 | 6 |
| | Ironstone balls in a band (*Avicula braamburiensis*) | 1 | 0 |
| | Subcalcareous, partly shelly, bed | 2 | 0 |
| | Ironstone balls in a band | 0 | 6 |
| | Calcareous bed, with *Belemnites giganteus* at the top, *Ostrea Marshii*, &c. | 2 | 4 |
| | Sulphurous laminated shale, with nodular ferruginous top | 1 | 8 |

On the north side of the island, as already observed, the upper part is wanting; the uppermost bed seen is the band of ironstone balls with *Avicula*.

The next series of beds, marked *e* 1, is found nearly alike on both sides or the island in the upper members, but very unlike in the lower members.

Commencing in the south, we have, mostly of freshwater or estuary origin:—

| | | ft. | in. |
|---|---|---|---|
| Sandstone and Shale ($e^3$), 19 ft. . . | Hard sharp laminated sandstone, with thin lines of shale and distinct vertical joints . . . . . . . . . . | 5 | 0 |
| | Shale, dark and "coaly" at top and bottom; the middle occasionally resembles "seat earth" . . . . . . | 5 | 0 |
| | "Pipy" white sandstone, passing downward to "seat earth," and still lower to shale with ironstone pins . . | 5 | 0 |
| | Lumpy sandstone, partly dotted with ironstone, jet, and wood. Forms resembling *Lutraria*, *Modiola*, but not known for certain to be organic . . . . 2 ft. 6 in. to | 4 | 0 |
| Coal Series ($e^2$), 12 ft. 8 in. . . | Dark laminated curled COAL shale, with many *plants*, and especially *Equisetites columnaris*. Here is a "sulphur* line" . . . . . . . . . . . . . . . | 1 | 8 |
| | Sandy grey laminated shales, or sandstone, a little pipy. | 2 | 0 |
| | Shales, with a thin sandstone layer and dark COAL bands, many plants . . . . . . . . . . . . 8 ft. to | 9 | 0 |

In the cliffs on the north side of the island, we have, wholly or mostly of freshwater or estuary origin, a slightly varied series:—

| | | | ft. | in. |
|---|---|---|---|---|
| Sandstone and Shale ($e^3$), 18 ft. 6 in. . . | Brown sharp laminated sandstone, with fine shale . . | | 5 | 0 |
| | Pale shale . . . . . . . . . . . . . . . | 4 ft. | 6 | 0 |
| | Dark shale . . . . . . . . . . . . . . . | 2 ft. | | |
| | Soft pipy sandstone . . . . . . . . . | 1 ft. 6 in. | 4 | 3 |
| | Pale pipy shale . . . . . . . . . . . | 1 ft. 6 in. | | |
| | Dark shale . . . . . . . . . . . . | 1 ft. 3 in. | | |
| | White pipy sandstone . . . . . . . . . . . . | | 3 | 3 |
| Coal Series ($e^2$), 12 ft. 1 in. . . | Dark shale and COAL in waved laminæ (*Equisetites*) | 6 in. | 1 | 10 |
| | Pipy pale sandstone . . . . . . . . . . . | 10 in. | | |
| | Coaly shale . . . . . . . . . . . . . . | 6 in. | | |
| | Laminated shaly sandstone or sandy shale . . . . . | | 1 | 10 |
| | Pale laminated sandstone and shale . . . | 1 ft. 6 in. | 8 | 5 |
| | Dark laminated shale . . . . . . . . . | 1 ft. 3 in. | | |
| | Lumpy white sandstone . . . . . . . . | 1 ft. 9 in. | | |
| | Pale shale, with very fine and numerous plants and ironstone pins—*Anodon* . . . . . . . . | 1 ft. 8 in. | | |
| | Shale with COAL streaks (pyritous layer at top) | 1 ft. 3 in. | | |
| | COAL-bed, crossed by "cleat," and composed of marine or mostly marine plants . . . . . . . . . | 1 ft. | | |

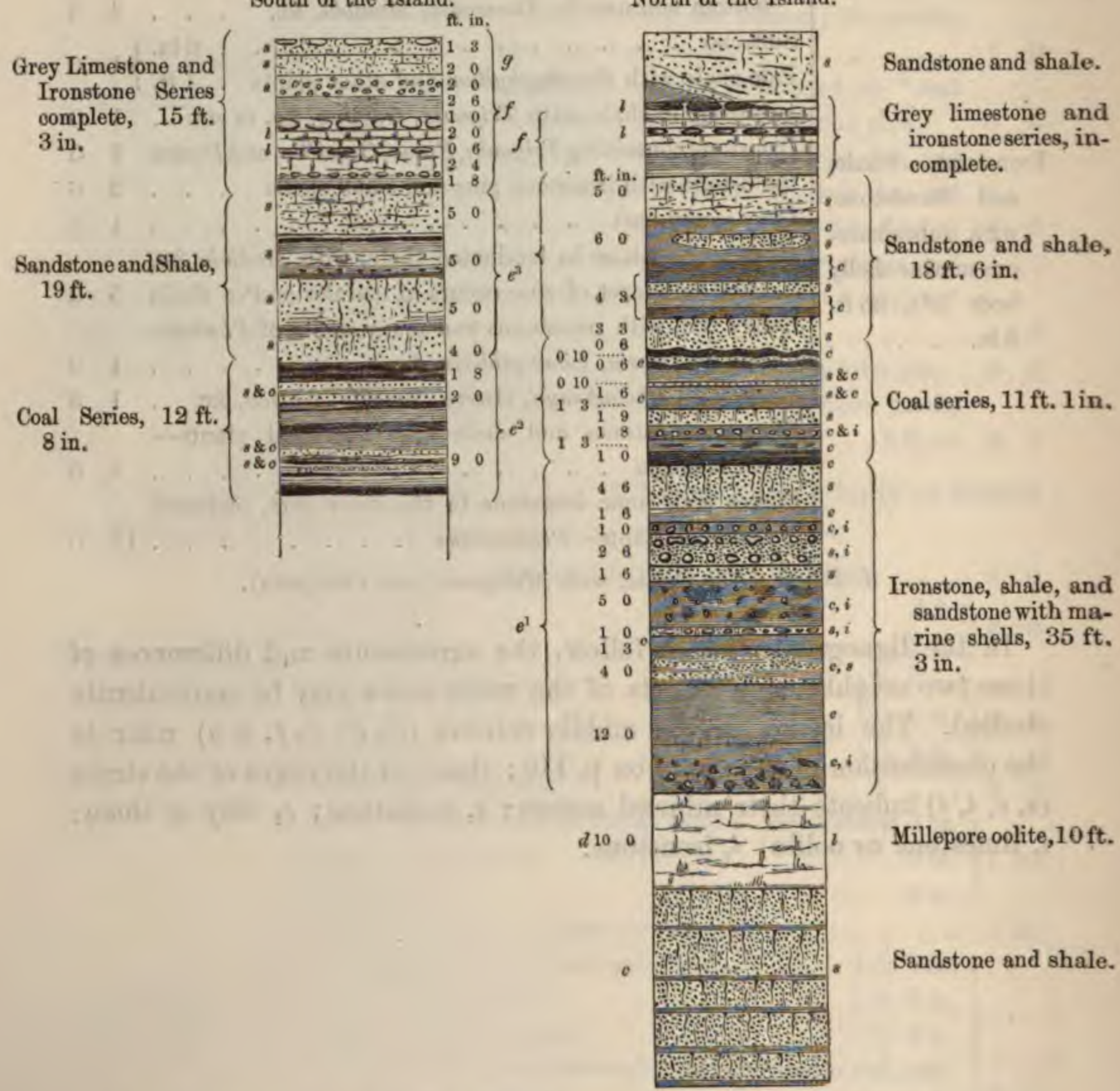
* Such yellow lines are marked by efflorescent sulphate of iron and some free sulphur, derived from decomposed bisulphuret of iron.

| | | ft. | in. |
|---|---|---|---|
| Ironstone, Shale, and Sandstone, with subcalcareous marine shelly beds ($e^1$), 35 ft. 3 in. . . . . | Sandstone with partings of shale, the top "pipy," the bottom laminated—*Tancredia, Modiola,* &c. . . . | 4 | 6 |
| | Soft clay . . . . . . . . . . . . . . . . 6 in.<br>Pale shale with *Brachyphyllum* and other plants . 1 ft. | 1 | 6 |
| | Ironstone in shale, with *Trigonia, Greslya,* &c. *in situ* . | 1 | 0 |
| | Ironstone containing *Trigonia, Pinna, Gervillia,* and *Pecten* | 1 | 0 |
| | Sandstone with ironstone pins and small shells . . . | 2 | 6 |
| | Grey sandy part . . . . . . . . . . . . . . | 1 | 6 |
| | Nodular ironstone in laminated shale, with *Modiola* &c. Here sulphuret of zinc occurs in nodules and in shells | 5 | 0 |
| | Sandy bed, with ironstones and many shells of *Pholadomya acuticosta, Lima gibbosa,* &c. . . . . . . . | 1 | 0 |
| | Shale with *Pholadomya, Ostrea, Avicula, Natica,* &c. . | 1 | 3 |
| | Skerry sandstones and shale with scattered plants—*Pholadomya* . . . . . . . . . . . . . . . | 4 | 0 |
| | Shales with some ironstone in the lower part, scattered traces of plants—*Pentacrinus* . . . . . . . . . | 12 | 0 |

*d.* Below is the Oolite, with *Millepora* (now *Cricopora*).

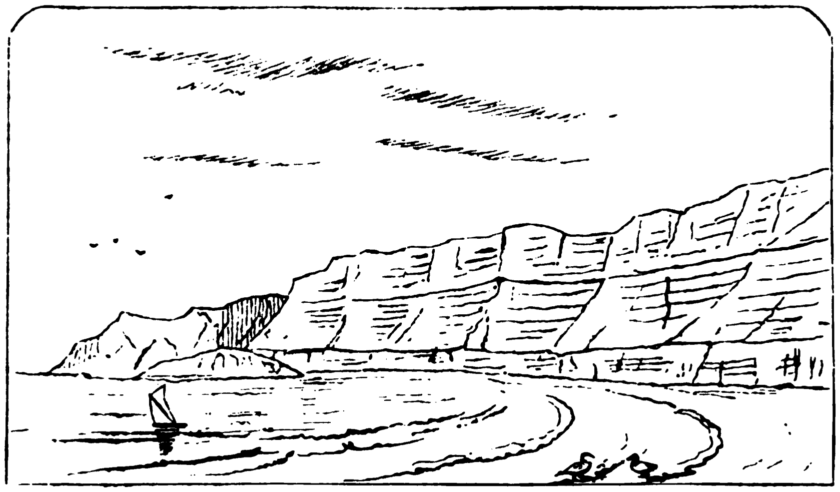
In the lignographs which follow, the agreements and differences of those two neighbouring aspects of the same series may be conveniently studied. The letters in the middle column ($e^1$, $e^2$, $e^3$, $f$, & $g$) refer to the classification of the strata on p. 110; those on the edges of the strata ($s$, $c$, $l$, $i$) indicate their mineral nature: $s$, sandstone; $c$, clay or shale; $l$, limestone or oolite; $i$, ironstone.

*Sections at Gristhorpe.*




Turning round the ruinous steeps of sandstone and shale, and crossing the fault, we find ourselves in front of one of the grandest precipices on the Yorkshire coast, called Red Cliff, which rises abruptly 285 feet above high water, and consists of the same strata as Gristhorpe Cliff. At the top the lower portions of the calcareous grit make a firm battlement;

and beneath them are the grey alternations, which so gradually change into Oxford Clay that no very distinct line can be drawn. The Kelloway




Red Cliff, from the north, 1855.

rock beneath is completely exhibited, with a thickness of 30 feet; the clay beneath, with *Glyphia*, can be seen occasionally; and the Cornbrash, with its characteristic fossils and of somewhat greater thickness than under Gristhorpe Cliff, makes a distinct ledge on the shore. A few fossils may be found among the fallen fragments which lie in heaps along the rough path, under the perishing and, on that account, perilous precipices of Red Cliff. Those who look closely as they approach the path leading up by Cayton Mill may gather magnetic ironsand; and in the great drift-mass of the cliffs a dividing bed of sands and gravel may be seen. All these strata are cut off, and made to terminate abruptly, by the rapid descent from Red Cliff to the large hollow filled with drift above Cayton Mill; beyond which is an unexpected cliff of calcareous grit sunk upwards of 200 feet below its general level, and based on the Oxford Clay. No doubt this is owing to some ancient subsidence or sliding of a part of the hill above. This part of the coast suggests the idea of a preglacial connexion of the old hollow of Pickering Vale with the German Ocean. Remove the drift which has been accumulated on the summit of drainage between the sea and the Derwent (that is, restore the ancient condition of things),

and the obscure village of Cayton might become an emporium of commerce. The summit referred to is less than 200 feet above the sea.

The Millepore-oolite sinks below low water before reaching Red Cliff; and all the strata above it bend a little downwards, and successively form scars; but suddenly the scars are all terminated by a straight line directed to N. 25° W., a common direction of joints. On tracing this line backward to the cliff we find it connected with a very remarkable dislocation or slip of the strata, which may be understood from the representation in the general section. On the left of the line of this dislocation the lower part of the Oxford Clay is opposed to the bottom of the calcareous grit on the right; the Kelloway on the left meets the top of the Oxford Clay on the right, whilst the Kelloway on the right meets the carbonaceous sandstone and shale on the left. The extent of the dislocation is about 140 feet; its direction agrees with the well-known observation of miners, that "the fault dips or underlies on the sunken side"—an observation which may be frequently verified on this coast of Yorkshire.

Immediately beyond rises the lower portion of the Carbonaceous series, and, at the prominent point called Ewe Nab, ascends so far into the cliff that the oolitic beds, which were before seen at the island on the north side of Gristhorpe Bay, appear above the level of high water.

Ewe Nab, as the picturesque headland was called when I first examined the coast, though the Ordnance Survey has not preserved the name, presents an interesting variation of the appearances connected with the Bath-Oolite series. On a first view it seems as if the shelly beds (*f*) above the Millepore-rock were deficient; but careful search has both disclosed them and the reason of their obscurity. My section, as drawn in 1828, refers to the seaward face at the extremity of the anticlinal promontory. The following description was written in 1872:—

Drift on the top.

(*f*) Place of the grey-limestone beds.

| | | |
|---|---|---|
| (*e*) | 5 feet. | Sharp-angular-sandstone beds, as usual below the calcareous beds. |
| | 20 „ | Shales and grits.<br>Dark shales. |
| | 6 „ | Irregular sandstone. |
| | 20 „ | Black shale and rough sandstone.<br>Dark shale. |
| | 20 „ | Sandstone with some scattered ironstone.<br>Sandstone knotted and banded with ironstone. |

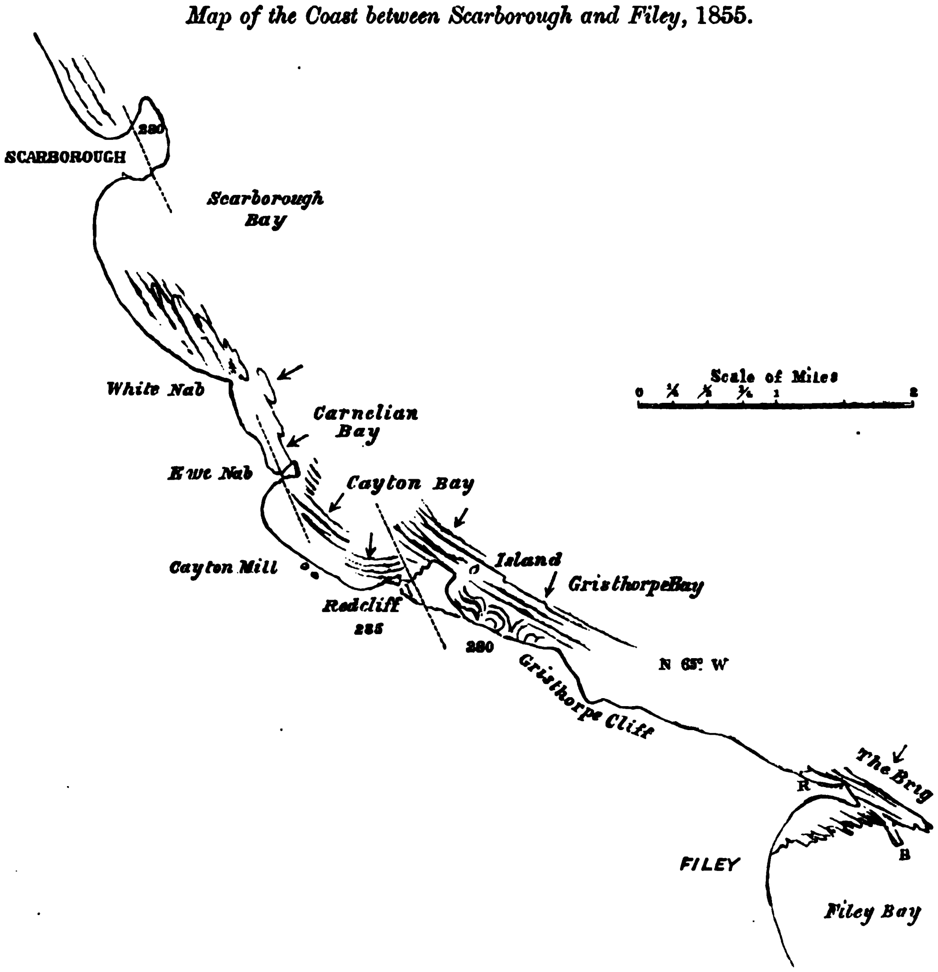
(*d*) Oolite, with ferruginous top, *Cricopora, Pentacrinites, Trigonia*, &c. The blocks large and solid, texture in part close-grained oolite.

The Millepore rock extends in broad floors on the south side of the promontory, till, with all the upper beds, it is cut off by a fault, which, ranging N.N.W. and dipping W.S.W., throws down the strata in that direction about 50 feet. The grey limestone with its characteristic fossils (*Belemnites giganteus, Ostrea Marshii*, &c.) is thus displaced so as to be only a little above the level of the Millepore-rock. The fault is a wide fissure filled with crushed shale and portions of the adjoining rocks; and on the eastern face a narrow slip of rocks lies steeply inclined parallel to the fissure-plane.

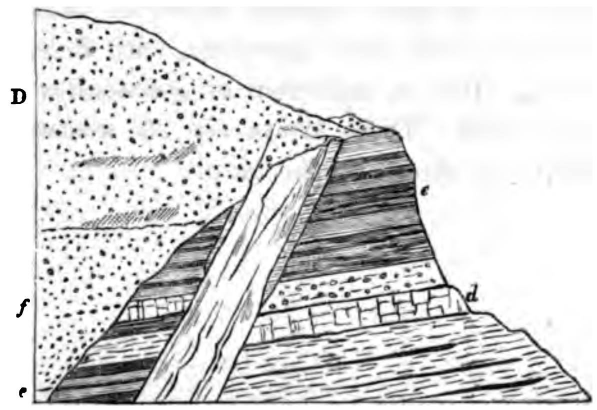
What makes this place the more singular is the very narrow wall of rock which remains on the western side of the fissure, under a deep deposit of drift which fills a large space in Cayton Bay.

Looking southward we trace the line of the fault in a direction toward Cayton Mill, and the largely exposed ridges of Millepore-oolite and beds above it, including the grey limestone, with *Belemnites giganteus* and *Ostrea Marshii*. Here a specimen of *Ammonites Humphriesianus* occurred to me in 1855. These strata dip 26° westward, their strike being N.W. and S.E., as shown on the Map.

*Map of the Coast between Scarborough and Filey*, 1855.




The numerals give the heights in feet. Arrows show the dips, dotted lines the faults. R. The Roman Villa. B. The supposed ancient breakwater.




Fault at Ewe Nab, looking north.

Turning round Ewe Nab in a northerly direction we find the beds declining till they are cut through by the fault, which on this side of the promontory has hardly any remains of the western wall. On the shore the line of disturbance is marked by a narrow ridge of the grey limestone with *Belemnites giganteus*, placed vertically along the truncated edges of the horizontally bedded sandstones, with spar veins, which form the eastern fault-wall. The disturbance points to the drawbridge under Scarborough earth, where a fault is observed in the same direction.

The oolitic beds which here present their huge blocks to the waves are so very similar to those described near the above-mentioned island as to need no additional description, further than to notice that the *Milleporæ* are here broken and less plentiful, and shells perhaps not so scarce; but the carbonaceous beds above them are different.

Carbonaceous shale and sandstone, mixed with much diluvium, occupy the low sea-cliffs of Carnelian Bay, under irregular broken slopes of diluvium. These appearances continue to the point of rocks called White Nab, where the tide flows round a little island, once as conspicuous as that which formerly stood at the north point of Gristhorpe Bay.

As at Gristhorpe and at Ewe Nab, so at White Nab, the beds rise gradually from the south to a moderate height, and again fall gently towards the north. The series here exhibited in broad shelly floors belongs to the grey limestone (*f*) considerably above the Millepore oolite of Ewe Nab, which is not seen again to the northward till we reach Cloughton Wyke. My observations in 1828 gave the following series:—

Mass of carbonaceous sandstone, with irregular interpolations of shale. In this layer of sandstone lie equisetiform and other plants, besides large branches of wood.

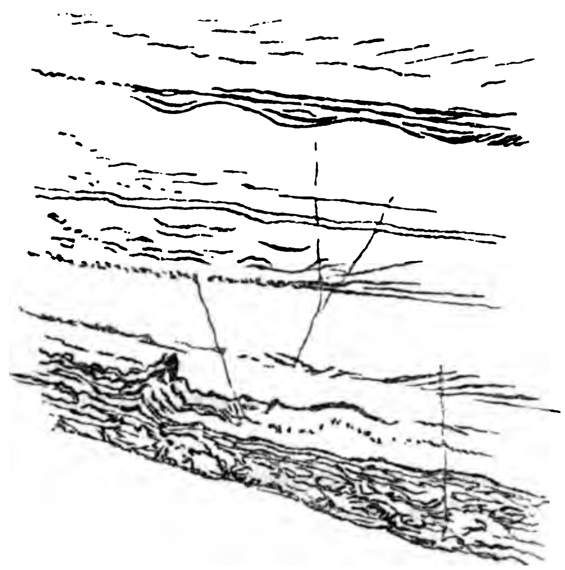
A regular bluish or yellowish bed, occasionally fissile; it then contains a few casts of bivalve shells, becomes very calcareous, and much resembles the "roadstone" of Brandsby. Represents the rough argillo-calcareous beds with layers of septariate ironstone, full of shells, and interspersed masses of soft large-grained oolite.

The uppermost layer is soft and shaly.

Of the fossils found at the White Nab, *Gervilliæ*, *Aviculæ*, and short thick Belemnites are among the most common. A great quantity of stone has been taken from these calcareous beds for Scarborough piers, where the large Belemnites may be seen in many of the blocks. Lately I observed the following series of beds thus exposed in these excavations and in the cliff (1872):—

4. Shales and sandstones.
3. Thick beds of sandstone partially undulated and laminated with thin dark and pale shales, carbonaceous layers, drift-coal, and fragments of wood. Toward the bottom the dark layers are irregularly twisted and dotted.
2. Ironstone lumps and layers, with sandy shales, locally shelly. 5 or 6 feet.
1. The "Nab rock" or grey limestone, of which four beds appear, making 8 or 9 feet of shelly subcalcareous rock, viz.:—

$$\left\{\begin{array}{ll} 1\text{ ft. } 6\text{ in.} & \\ 2 \quad 6 & \\ 3 \quad 0 & \\ 1 \quad 0 & \end{array}\right. \quad \left.\begin{array}{l} 2 \quad 6 \\ 3 \quad 0 \\ 1 \quad 0 \end{array}\right\}\text{most solid part of the rock.}$$



4

3

2

1

Proceeding along the shore we find the calcareous and ironstone beds exposed in broad flat scars at low water, and extending, with some inter-

ruptions, to Ramsden Scar, nearly opposite the bathing-machines at Scarborough. The lower part of the cliff, from White Nab nearly to the Spaw, is kept by the carbonaceous grit; and above, in irregular often grassy cliffs, lie the carbonaceous shale and thin sandstones: the highest point of this inland cliff, opposite Wheatcroft's farm, 278 feet high, is capped by the Cornbrash and Kelloway rocks. The calcareous and irony strata have their long, straight, intersecting fissures often lined with double laminæ or septa of oxide of iron, between which sometimes occurs a white, compact, soft, smooth substance ("Scarbroite"), which the Rev. W. V. Vernon ascertained to be a compound of alumina and silica with water. Exactly similar septa, and occasionally the same aluminous substance, occur in the superincumbent variable bed of sandstone; and, in addition, this bed presents a number of ochraceous belts or zones parallel to the margins of its blocks, thus beautifully variegating the blue or white colour of the stone.

It is interesting to observe, in this walk along the south sands of Scarborough, between White Nab and the Spaw, the peculiar appearance of the carbonaceous sandstone. The frequent and remarkable curvatures

Bed of Sandstone near Scarborough.

of the beds, the unequal intermixture of shale among them, and the dispersion of carbonaceous fragments through the mass leave no doubt of the agitation of the water which left this curious deposit. The accu-

mulation of diluvial matter increases continually northward from the high point of Kelloway rock opposite Wheatcroft's; and it occupies the whole cliff from the Spaw to the bridge. It is, in general, clay filled with pebbles of all kinds and magnitudes; the largest masses are either Shap-fell granite, Mountain-limestone, or basalt. Among the most abundant are porphyries, of which some belong, I think, to the Cumberland mountains; others may, perhaps, be referred to Scotland. The agates, which have been transported along with trap-rocks from Scotland or the north of Europe, are comparatively rare. In a few places the diluvial matter swept from some particular line of country seems to be exclusively aggregated together. This is well seen behind the Spaw, where the gravel consists almost entirely of fragments of Lias and moorland sandstones. Here lie many *Ammonitæ*, *Pectines*, *Gryphææ*, &c., characteristic of the Lias formation.

In cutting the cliff above the terrace walk at Scarborough, a seeming dislocation in the diluvium has been exposed. If the appearances may be trusted, two layers of wet sand have been depressed several feet on the northern side. But the inequality of the depression in the two layers, and the seeming dislocation not extending into the gravel beneath, are circumstances never observed in a determinate dislocation of strata. The cliff over the Spaw varies from 151 to 171 feet in height above high water.

That part of Scarborough emphatically called the Cliff, is from 90 to 110 feet above high water; from here the slope grows continually flatter to Bland's cliff; and beyond this point the whole shore is occupied by streets as far as the commencement of the outer pier. Here the steeps of the Castle Hill rise suddenly from the water, and, further on, reach an elevation of 270 feet; but part of the Castle Garth is, perhaps, 15 feet higher. The first rock which is seen above the pier is a ferruginous sandstone with fossil shells, which is ascertained to be identical with the rock of Kelloway bridge in Wiltshire. Above lies the grey argillaceous earth which occupies the place of the Oxford Clay; this gradually passes into the calcareous grit; and some beds of the coralline oolite surmount the whole. The strata decline in the eastern face of

the hill, so that the Kelloway rock sinks below the level of high water, and at a projecting point the Oxford Clay keeps the foot of the cliff; but soon rising again, where the hill fronts the north, these strata ascend towards the drawbridge. The Fort on the northern face of the hill is levelled on nearly the lower beds of coralline oolite. Of this rock 30 feet appear on the hill above; its whole thickness here is nearly 40 feet. Below are about 18 feet of solid calcareous grit beds; these rest on three layers of hard calcareo-siliceous balls lying in soft yellow sand, 28 feet thick; then succeed 50 feet of calcareous grit, hard above but graduating below to the next stratum, the Oxford Clay, which, being 135 feet thick, occupies the remainder of the hill to high-water mark.

These strata, rising towards the drawbridge, have been subjected to a very uncommon dislocation, the effect of which is the uplifting of the Kelloway rock to the level of the lower part of the calcareous grit. Kelloway fossils are found in this uplifted portion on the north side of the drawbridge*, 200 feet above the sea. This uplifted portion is very narrow, and it is not nearly so distinct as, from necessity, the general section represents it. Bushel's fort is upon the lowest soft part of the calcareous grit, which can hardly be distingished from the Oxford Clay. The stratum so named is found in the upper part of the cliffs beyond; whilst below it occurs the Kelloway rock, rich in *Ammonitæ*, *Gryphææ*, *Aviculæ*, &c. The Cornbrash is found beneath, full of *Terebratulæ*, *Gresslyæ*, *Trigoniæ*, *Ostreæ*, &c.; and its blocks, strewed on the sands, afford a rich harvest to the geologist. Still lower are the shales and sandstones of the carbonaceous grit. Scarborough Castle Hill, therefore, agrees in general composition with Gristhorpe and Red Cliffs; but its summit is crowned with the oolite, which does not occur on them. Further, since in none of the cliffs from Filey to Scarborough do we find any of the superior calcareous grit, which is found above the oolite near Kirby-Moorside and Helmsley, it is certain that on the Yorkshire

* Dr. William Smith discovered this singular fault, and communicated it to me: his eagerness on the occasion led him to overstrained exertion; and the consequences was a very alarming privation of muscular power in the legs, from which, however, after some months, he recovered entirely.

coast this oolitic series is imperfect by the deficiency of its upper members. That such deficiency is aboriginal no one will suppose who considers the deep-cut valleys and vast heaps of diluvium in the country about Scarborough; for these bring irrefragable testimony to the effect of wide-spreading and powerful denudations. In order, therefore, to gain a complete knowledge of this oolitic formation, it is necessary to study the coast and the interior together; the cliffs against the sea must be compared with the quarries and watercourses inland, before such a table of stratification can be prepared as I have given in the previous pages of this work. Moreover it must be observed that nowhere on this coast do we find those lowest layers of the Kimmeridge Clay which at Kirby-Moorside and west of Helmsley furnish the characteristic *Ostrea deltoidea*. These beds have yielded to the same diluvial impetus. But, with these exceptions, the series on the coast is complete, from the top of the Chalk to nearly the base of the Lias, and junctions may be examined of all the adjacent strata.

As the Oxford Clay, Kelloway rock, and Cornbrash are nowhere on the coast better seen than at Scarborough, and as we shall have no other opportunity of noticing them till we come to treat of their organic contents, I shall take this opportunity of adding some notice of their general character and appearance.

The chief reason for giving the name of Oxford Clay to the grey argillaceous earth of Scarborough Castle Hill, is its position between the well-determined strata of calcareous grit and Kelloway rock; for, independently of this circumstance, no particular affinity can be traced between the friable and rather sandy shale of Scarborough, and the tough blue clay of Oxford and Wiltshire; and the fossils of both situations are yet but imperfectly known. It is probable, indeed, that my enumeration of the fossils found in this stratum at Scarborough by Mr. Bean, Mr. Dunn, Dr. Smith, and Mr. Williamson (previously to 1829), may be found more extensive than a similar catalogue of those belonging to it in the south of England; and yet only a few years had elapsed since it was discovered to contain any.

The Kelloway rock agrees much better with its prototype, both in substance and organic remains. It is, indeed, seldom that specimens of mixed secondary sandstones procured from neighbouring parishes are more similar than some which may be selected from this stratum in Wiltshire and Yorkshire; and so complete is the affinity of the imbedded fossils, that it might be easy for the most practised eye to mistake the one for the other. In Yorkshire the Kelloway rock is a mixed sandstone, containing some carbonate of lime and some argillaceous particles of a greyish-yellow colour, changing to greenish grey when wet, and to brownish yellow when much impregnated with oxide of iron. The difference in its state of consolidation is singular: in some places it consists of loose unaggregated sand, containing hard, irony, and calcareous masses. At Hackness alone it is worked as a building-stone: it is there very soft in the quarry, and may be chiselled and wrought with the utmost facility. It has at the same time the property of hardening by exposure; and, possessing both beauty and durability, is a very valuable building-stone. Its durability is evinced by the condition of the stone in the ancient church at Hackness, which was probably built about the end of the thirteenth century; and its good effect in architecture may be seen to great advantage in the new church and new museum at Scarborough, and especially in the Museum of the Yorkshire Philosophical Society, in the construction of which blocks of great magnitude have been employed.

Its thickness is generally above 30 feet, at Scarborough 70 feet: the upper bed is usually very thick, hard, and irony, full of *Gryphææ*, *Belemnitæ*, &c., so as to be unfit for building. In the quarry at Hackness, *Ammonites Duncani*, *A. Kœnigi*, *A. sublævis*, &c., which so eminently characterize the stratum, lie on the top of the rock just below the Oxford Clay. At Scarborough they lie a little deeper in the stone. On account of its comparative hardness, the upper beds of this rock project on the hill-sides beyond the slopes of the incumbent clay, and form little buttresses beneath those remarkable "nabs" by which the calcareous grit is recognized in the vicinity of Scarborough.

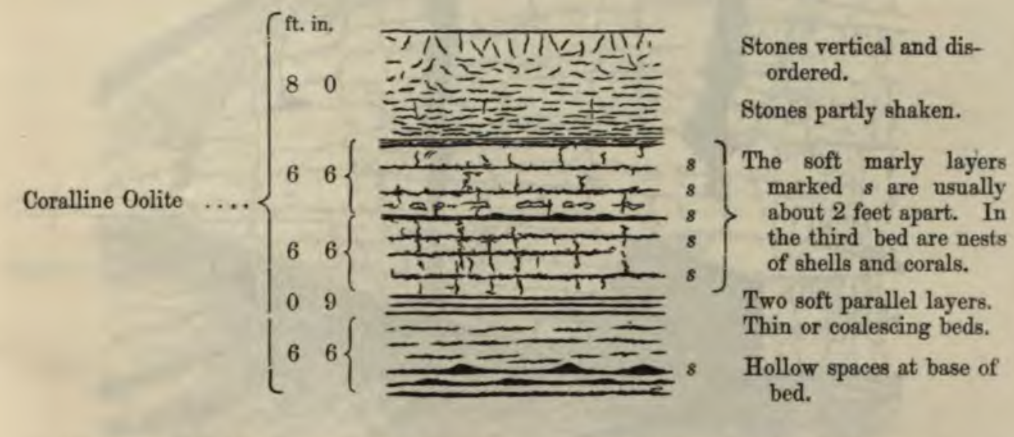
That stratum of the oolitic series which in the south of England

Mr. Smith named the "Cornbrash" is well known to be a very variable rock as to its substance and thickness, but remarkably well characterized by its fossils. It is by their aid that we have traced this thin and otherwise unimportant rock, with hardly a single interruption, from Dorsetshire to Lincolnshire. But it does not reach the northern limit of this county, does not reappear beyond the Humber in the country about Cave, and, as already stated, is rather inferred than positively traced about Malton and Thirsk. It is therefore by organic fossils and geological position alone that we can expect to recognize the Cornbrash on the coast of Yorkshire. By these characters it may be satisfactorily identified; or, at any rate, a characteristic marine layer which marks the close of the estuarine condition of this part of the oolitic series may be admitted as a near equivalent in point of time. It usually appears as a single, thick, fissile, calcareous bed, lying almost in contact with the bottom of the Kelloway rock, but eminently distinguished from it by the nature of its substance and the shells with which it is filled. Without close attention, so thin a layer can hardly be traced along the cliffs; and it is therefore not surprising that its inland course is rather assumed than proved. In the romantic cliffs which overhang a part of Newtondale, however, this rock is very conspicuous. Below it is the carbonaceous series of shales and sandstones, already noticed, and the other members of the Bath-oolite group, whose northward extension is to be described in the next chapter.

It may assist the reader who has followed the descriptions now given of the coast-sections from Filey to Scarborough, if he turns to the Map, p. 120, and considers the strikes of the beds and directions of the faults there represented. First he will remark a general conformity of the strike of the beds and the line of the coast, though to this are limited exceptions. The dip is generally inland; the shore is wasted into bays, where, more than elsewhere, argillaceous strata or abundant drift have betrayed the seemingly rock-bound coast. Under Gristhorpe Cliff the estuarine sandstones and shales exhibit curious curvatures of outcrop in contrast with the straight lines of the marine beds. The faults in Red Cliff, Ewe Nab, and Scarborough Castle Hill run in parallel directions.

Probably the two last-mentioned are parts of one line of movement, very strongly marked by vertical beds on the north side of Ewe Nab, and steep dips in Cayton Bay. Since this Map was sketched, the little island which was conspicuous at the north boundary of Gristhorpe Bay has been swept away; but its rocky base remains to resist the tide.

No part of the Yorkshire coast gives opportunity for observing a complete section of the Coralline Oolite. The lower portions of the rock, and the manner of their connexion with the calcareous grit below, are well exhibited at Filey, and may be with some trouble observed in the Castle Hill of Scarborough. Passing inland we find at Seamer about 30 feet of the oolite, largely quarried for lime-burning. The uppermost bands, 8 feet in thickness, are in thin and somewhat displaced layers (a common fact in oolitic countries); and the most superficial parts exhibit vertically disarranged fragments. The strata below, usually about 2 feet thick, are divided by softer marly partings, and toward the bottom hollow spaces appear on one of these divisions; occasioned by removal of the soft material. Water was the agent; and it is quite intelligible that such hollows may have been occasionally enlarged to the form and dimensions of a continuous cave, like that of Kirkdale.

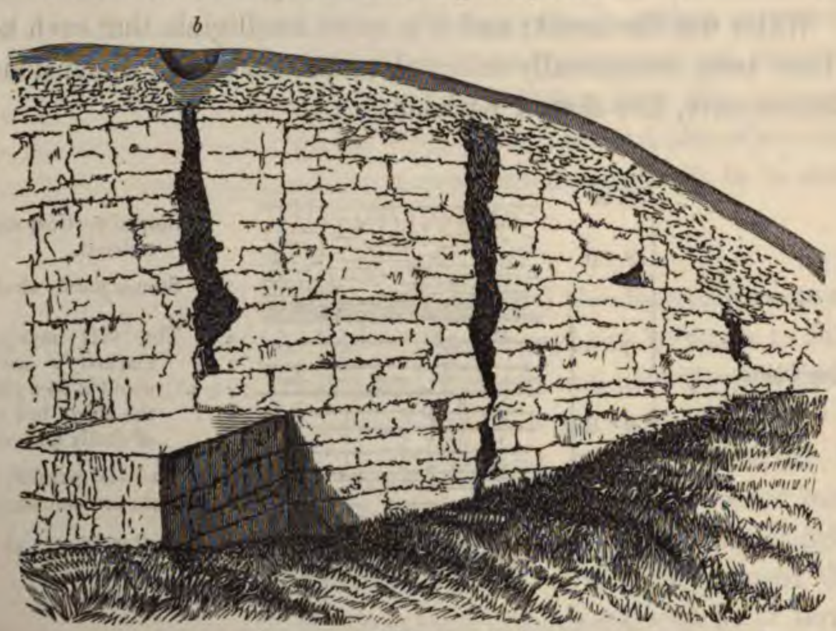



Some of the beds are largely pisolitic; one 2 feet thick is almost composed of *Montlivaltia* and *Thecosmilia*, justifying to some extent the

title of "Coral Rag," so often used in the south of England. Fossils are not plentiful; but *Ammonites, Natica, Chemnitzia, Perna,* occur in the rock. The soft bands contain in some places many shells and echinital spines.

There is no drift over these quarries; but close by the station the rock is covered by pebbly layers, 8 or 10 feet thick, dug for ballast, in which, close to the rock, I obtained fragments of ordinary littoral shells, 150 feet above the sea.

Similar characters appear in the oolite quarries along the north side of the Vale of Pickering; and in the valley under the old castle, north of this town, the upper surface of the rock is seen to be covered with 8, 10, or more feet of the grey sands and sandstone, which here constitute the upper calcareous grit. Near Kirkdale and Helmsley the same general characters are recognized; and there, as every where in this oolitic district, large joints, mostly ranging to the N.N.W., and nearly vertical, divide the mass of the rock, as in the following diagram.




Quarry of Oolite near Helmsley.

At *b* is a hemispherical excavation for pre-Roman burial, such as are

not uncommon in dry situations on gravel or over rock, both in North and South Britain.

Near Malton about 50 feet is the fair measure of thickness, though rarely more than 30 appear in one quarry. On the road from Malton to Settrington, a large quarry in the middle part of the oolite, remarkably poor in fossils, gives beautiful crystals of carbonate of lime, in cavities from which Coral has been dissolved away.

*Section of Calcareous Grit at Hutton Ambo.*

Oolite above.

| | ft. | in. | |
|---|---|---|---|
| Calcareous grit.................... | 9 | 0 | Oolitic grit. |
| Grit and sandy alternation, 49 ft. 9 in.. | 4 | 0 | Hard grit. |
| | 4 | 0 | Soft. |
| | 3 | 0 | Hard. |
| | 4 | 0 | Soft. |
| | 3 | 0 | Hard. |
| | 5 | 0 | Soft. |
| | 3 | 0 | Hard. |
| | 0 | 9 | Soft. |
| | 0 | 9 | Hard. |
| | 4 | 0 | Soft. |
| | 1 | 0 | Hard. |
| | 2 | 0 | Soft. |
| | 0 | 9 | Hard. |
| | 5 | 0 | Soft. |
| | 1 | 0 | Hard. |
| | 4 | 6 | Soft. |
| | 4 | 0 | Hard. |
| Sandy beds passing to Oxford Clay, 22 ft. | 20 | 0 | Soft. |
| | 2 | 0 | Hard. |
| | | | Soft. |

Oxford Clay below.

The lower part of the calcareous grit, which is not easy of access in the steep cliffs of Gristhorpe and Redcliff, or in the north front of Scarborough Castle Hill, can be seen in the interior about Lastingham and in Newtondale, and along the west front of the Hambleton hills, but nowhere so conveniently or completely as on the railway at Hutton Ambo, west of Malton. Here about 80 feet of hard and soft sandstone, (the former prevailing above, the latter growing thick below) furnish a complete transition from the sandy Oxford Clay below to the partially sandy oolite above. The uppermost part, 9 feet thick, is irregularly oolitic, and it is succeeded above by ordinary oolite, and in places pisolitic rock. None of the hard beds of sandstone below exceeds 4 feet in thickness; the lowest observed is 2 feet thick, and is covered by 20 feet of sand, indicating the change from the Oxford Clay below. This deposit is here remarkably poor in fossils; while, on the contrary, about Hovingham, Castle Howard, and Birdsall it is rather rich.

# CHAPTER XI.

## CLIFFS NORTH OF SCARBOROUGH.

FROM low-water mark on the shore, beneath the drawbridge, the Upper Carbonaceous series rises gradually, till at length, the Cornbrash having terminated, it possesses the whole stratified portion of the cliff; but a great quantity of diluvial clay and pebbles lies upon it, thickening towards Peaseholm beck. In one of my visits to Scarborough I made a careful examination of these sandstones and shales for the purpose of discovering plants, and found a considerable number of zamiaceous leaves, which differed in some respects from those which are more frequent in the middle and lower shales; but they were in bad condition. This was not far from the place where the pleasure-pier now projects from the cliffs. The hill beyond the beck, on whose slope are some entrenchments, commonly termed Oliver's battery, is likewise composed of diluvium resting on shale and thin sandstones; and this character continues to the opening at Scalby beck. Here, on both sides of the stream, is a very interesting occurrence of granular iron-ore, like the coeval deposit already mentioned at Gristhorpe, in a solid nodular bed interlaminated with the sandstone. On the shore at different points north of Scarborough magnetic iron-ore in small grains abounds. It is supposed to be derived from the drift. On the thin sandstones near Scalby beck are found both the slender and the digitated leaves which have been referred to ferns under the genera *Cyclopteris* and *Sphenopteris*; but neither of these titles appears to be correct.

The cliffs from Scalby beck to the projecting point south of Cloughton Wyke are all less than 135 feet in height, and, as will be seen by the colouring of the section, are all composed of diluvial sand and sandstone gravel, resting upon shale and sandstone. The sandstone forms a series of low-water scars, on which it is interesting to trace the contrary

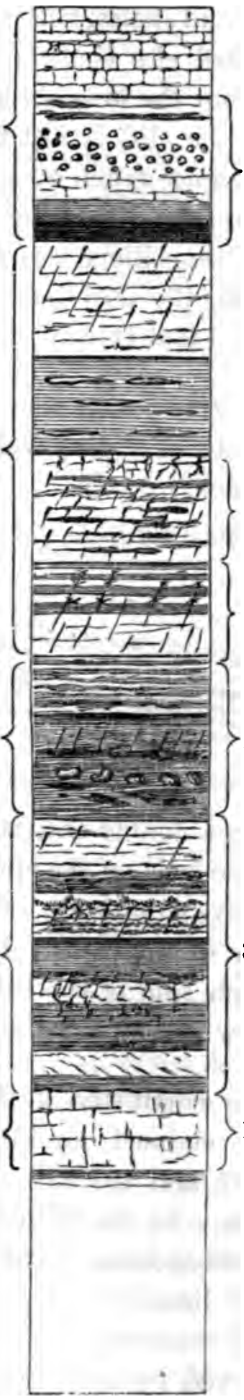
courses of the beds, depending on their irregular flexures and inclinations. Before arriving at Cloughton Wyke the lower and thicker beds of sandstone above mentioned rise to the summit of the cliff, and leave the shore to be occupied by the argillo-calcareous and sometimes oolitic beds, full of shells, which correspond to the Grey Limestone series of Gristhorpe and White Nab. The rocks here laid bare in the cliffs and on the shore lie in the following order:—

*g.* Block sandstone, on the top of the cliff, irony, and often spotted with carbonaceous fragments.

*f.*
- Shale, which wastes from under it. In the upper part principally lie the ironstone balls.
- Nodular, rather shaly calcareous bed, full of shells, 5 or 6 feet; the joints sparry and ochry.
- Shale, 1 foot 6 inches.
- Nodular bed like *c*, full of shells.
- Shale, 2 feet 6 inches.
- Soft calcareous layers full of shells.

*e.* Series of fissile and solid sandstones, ironstone, and shale-beds, here and there containing plants. Some beds waved like the tide-worn sand; others full of ramified masses very like but smaller than those in the calcareous grit.

These beds continue rising in the cliffs which encircle the bay of Cloughton Wyke, where incrustations happen from the water falling over them, and, beyond, ascend toward the summit of the far loftier cliffs between Cloughton and Haiburn Wyke. At a point about 200 yards north of the Wyke, or deepest indentation of the coast, we find in the cliffs, which exceed 100 feet, and in the shore strewn with large fallen blocks of sandstone, the excellent section which follows:—

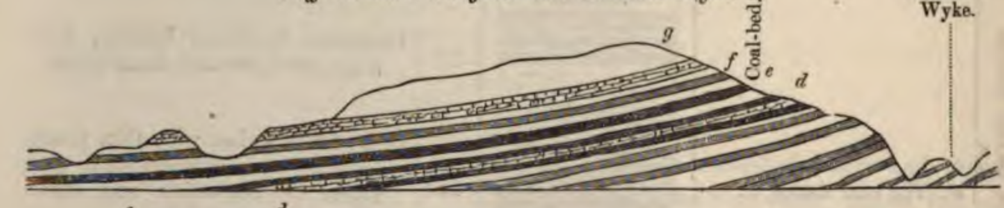


| | | feet. | |
|---|---|---|---|
| | *f.* The grey limestone shales and Ironstone series, 30 feet ............ | 12 | Mostly solid rock. |
| | | 18 | Ironstone, with calcareous and shaly beds. |
| MIDDLE SHALE SERIES. | *e*³. Grits and shales, 54 feet............ | 15 | Strong angular sandstone, usual at the base of the Grey Limestone series. |
| | | 12 | Shale, with thin sandstone. |
| | | 15 | Soft sandstones, pipy above and laminated with shale below; weathers like shale; jet. |
| | | 12 | Flagstone, in broad laminæ, with shale above, in solid floors below. |
| | *e*². The coal shales .... | 21 | Great Shale series, with thin sandy laminæ, an ironstone-band, and layers of *Equisetites* and other plants; a thin coal-band. |
| | *e*¹. Grits and shales .... | 30 | Series of sandstones and shales, the former lumpy or laminated; the lowest is false-bedded. |
| | *d.* Millepore-oolite ........ | 10 | Oolite, with irregularly mixed and capping ironstone in variable beds, one often very thick. |

Below is a series of sandstones and shales, with some ironstone, jet, and carbonized plants. The northward rise continuing, some of these beds may be examined in succession; but the lower beds cannot well be traced toward Haiburn Wyke, though the cliff is 331 feet high, because of a slip or sunken portion of the precipice much overgrown with shrubs and disguised by loose blocks. Where the cliff rising from Cloughton Wyke attains a height of 240 feet, a little colliery was formerly worked in the shales below the grey limestone, the coal being mostly derived from Equisetites. It was found to be 1 foot thick.

This coal-seam, beneath the grey oolite, has been pretty extensively wrought in the interior moorlands, as at Maybecks on the Sneaton estate near Whitby, and in Danby beacon.

*Cliffs between Cloughton and Haiburn Wyke.*




The clear bands are sandstone, the shaded bands shale; *f*, the grey limestone; *d*, the Millepore-oolite.

There is a dislocation, perhaps a double one, at Haiburn Wyke; and I am not certain that the sandstone beds on the opposite sides are correctly referred to their respective relative situations; but the section was drawn after three careful examinations of the place. If it is correct, there are two faults, one running on each side of the little insulated cliff which shows the strata turned up a few yards on the north side.

The cliffs which begin on the north side of Haiburn Wyke are loftier than any which have hitherto claimed our attention. They continue rising with altitudes of 296, 387, and 497 feet, to the High Peak, which is about 585 feet above the sea. In the middle of this high range the uppermost rock (*g*) is the carbonaceous gritstone so frequently mentioned, and below it a series of limestone (*f*), shale (*e*), and sandstone, corresponding to those already enumerated at Cloughton Wyke. The Millepore-bed (*d*) was not observed by me in my former examination of

these cliffs*. Lower beds than these (*c*) also appear at the northern and southern extremities, but are obscured in the middle by what seems to be a very extensive slip of the superior heights.

As in a part of the Stainton cliffs the carbonaceous sandstone is seen lying upon the Oolitic series, whilst at Blue Wick and below the Peak the Lias appears, we obtain by uniting the observations the following section of nearly the whole of the Moorland series of rocks:—

| | feet. | | |
|---|---|---|---|
| (*g*) | 40. | *Estuarine* . . | Carbonaceous grit, containing black shale in lumps and layers, bits of carbonized wood, and striated culms, but apparently different from those of High Whitby. This rock is quarried on the edge of the cliff. |
| (*f*) | 30. | *Marine* . . . | Shale of a dark colour.<br>Shelly limestone, with large short *Belemnites giganteus*.<br>Shale.<br>Nodular shelly beds with fossils. |
| (*e*) | 120. | *Estuarine* . . | Sandstones and shales, with coal and some ironstone. |
| (*d*) | 10. | *Marine* . . . | The Millepore-bed. |
| (*c*) | 60. | *Estuarine* . . | Mostly sandstone beds, forming a rock about 60 feet thick, which may be traced without interruption from Haiburn Wyke to the summit of the cliff at the Peak; and from that point it appears on many of the cliffs to the northward, and in the interior moorlands, with much local variation and at different heights above the alum-shale. |

The series below, to the Lias, varies much in the arrangement of the beds of sandstone and shale, and still more in their aggregate thickness:—

feet.
(*e*) 200. A series of shales and sandstones in very frequent alternations, the former predominating so as to cause the cliff to waste, and generally to slope from the cap-rock above to the Sandstone series beneath; in a part of

* In a recent trip from Scarborough, the situation and range of the Millepore-bed were well seen from the deck of a steamer by Mr. Leckenby, Mr. Woodall, Mr. P. Cullen, and myself.

this series, at Haiburn Wyke, lie fossil plants resembling *Cycadaceæ*, ferns, *Equiseta*, &c.

feet.
(*e*) 60. Grit rocks and thin shales in irregular succession and of various thicknesses. They generally appear thus:—

20 feet of grit of a white colour.
6 to 10 feet of shale.
20 feet of grit; at its bottom is ironstone containing various plants, as Cycadiform fronds and ferns.
10 feet of irony and carbonaceous shale.

Conchiferous (*Dogger*) series analogous to the lower beds of the Inferior Oolite of Northampton, Bath, and Sherborne. This is best exposed at Blue Wick, and contains the following beds in downward order, as observed on several occasions before 1836:—

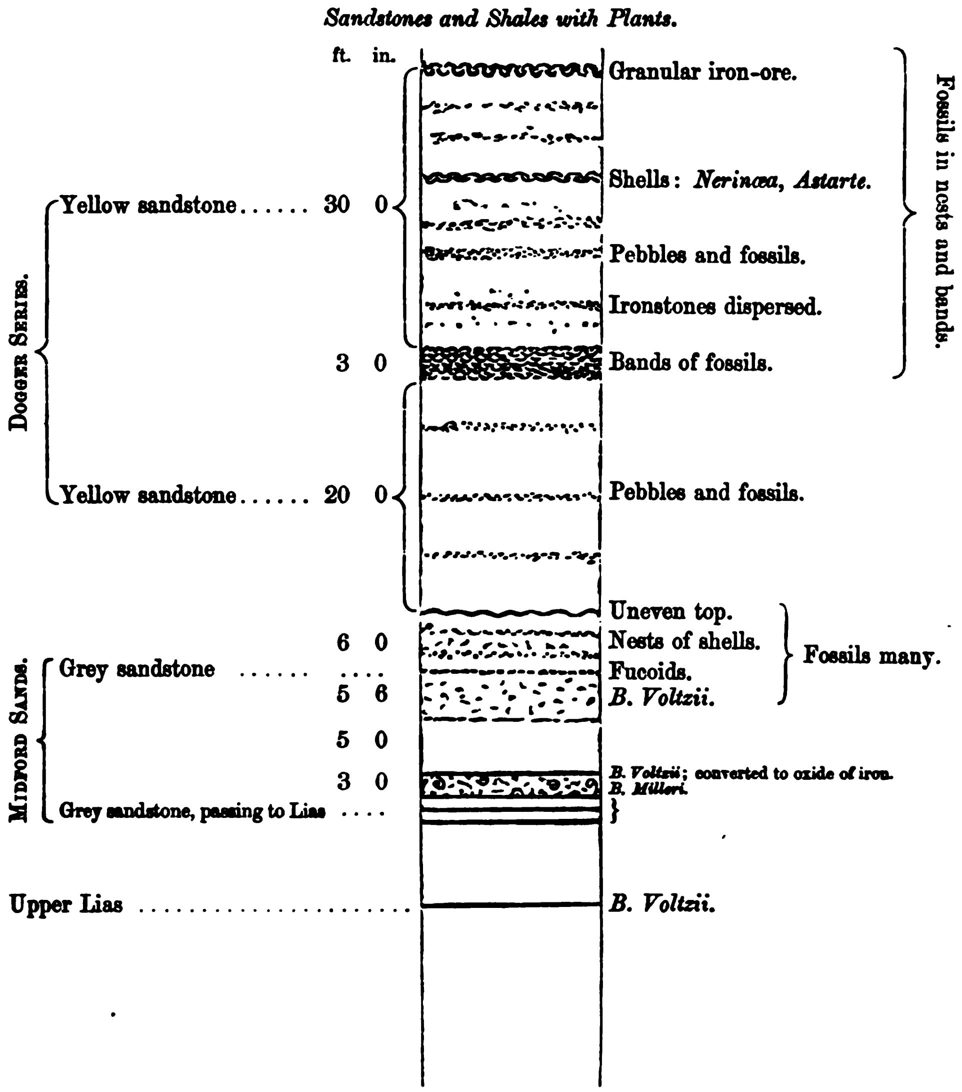
feet.
30. Fine-grained, yellow, micaceous, irony sandstone, in large blocks variously bedded and jointed, containing several layers of pebbles and shells (represented in the enlarged section by dotted lines); the upper one very ochraceous and full of many shells, as *Turritella muricata*, and *T. cingenda*, *Actæon*, *Trigonia*, *Astarte*, &c. The top is very irony, but without shells. A parting of shale, ironstone, &c.

20. Fine-grained, yellow, micaceous sandstone, in blocks of various forms, with nests or irony masses of *Serpulæ*, *Lingulæ*, &c., represented by dotted lines.

20. Grey, soft, micaceous, argillaceous sandstone, mostly fissile, but not regularly plated like the alum-shale, to which it gradually changes in the lower beds; divided like the Lias by long joints, and filled with subramose masses of the same substance, not unlike the beds at Cloughton. These beds form the scars which stretch from Blue Wick a short distance southward. On their surface lie irony nests of *Serpulæ*, *Belemnitæ*, *Aviculæ*, *Pinnæ*, &c.

Below are the rough, sandy upper beds of Lias shale, which lower down become regularly fissile, and are full of Ammonites, Belemnites, unioniform shells, &c.

On the occasion of my latest visit to this interesting spot, in 1867, with my friends Dr. Cookson and Mr. J. E. Lee, the following section of these Dogger beds was drawn, without reference to what had been observed on former occasions:—




## LIAS CLIFFS.

From Blue Wick, where it first appears, the Lias formation is seen along the whole shore by Whitby, Runswick, Staithes, Boulby, and Saltburn, and is everywhere washed by the sea, except in the space between Whitby and Sandsend, where it is depressed by extensive dislo-

T 2

cations. In consequence the cliffs assume a different appearance from those already described, and present different phenomena. Stupendously abrupt and separated by a very narrow space from deep water, it is often hazardous, and sometimes impracticable, to examine them from beneath. They vary in altitude, according to the character of the inland country and the pile of strata in the cliff. The great height of the Peak is owing to the truncation of the high ridge of Stow brow; and the superior elevation of Boulby is accompanied by an accumulation of the sandstone rocks at the top. There is no example, from the Peak to Saltburn, where any rock as high as the Millepore-bed appears in the cliff. Some of these strata do, indeed, appear at a short distance inland, as the oolitic limestone near Hawsker bottoms; but they never reach the sea-shore; and in our future descriptions we shall therefore notice only the subdivisions of the Lias and the variations in its sandstone covering.

Proceeding northward from Blue Wick, we find the Lias rising with extreme regularity to some distance beyond the Peak house, where it attains an elevation of 270 feet above high water. A sunken portion of the precipices here forms an undercliff, and leaves only the upper part of the Lias exposed below the conchiferous and plant-producing beds before described. But immediately beyond the scene changes: a great dislocation has happened; and the Lias beds are uplifted on the northern side of it to such a degree that some conchiferous beds, which are usually 300 feet deep in the Lias, appear considerably higher than the top of that formation on the south. This will be readily understood by referring to the section.

The uppermost of the beds thus exposed on the north side of this great dislocation belong to a thick series of sandy and irony conchiferous strata, which divide the Lias clay or shale into two principal parts, henceforward to be termed Upper and Lower Lias Shale. The highest part of the upper shale, as being peculiarly appropriated to the production of alum, is termed the alum-shale. The interposed irony and shelly strata are identical in geological characters with the marlstone and some associated beds of Lincolnshire, Rutland, and the midland counties, now commonly

termed "Middle Lias." In all these counties the marlstone is wonderfully prolific in fossils; and it is equally productive in the Yorkshire cliffs. At the Peak about 40 feet of this series appear, and yield abundance of *Rhynchonellæ*, *Dentalia*, *Aviculæ*, &c. Below these sandy beds is an immense escarpment of more than 300 feet, composed of the deeper Lias shale, with many layers of ironstone resting upon more solid floors of the same strata. In these solid beds, the lowest probably which are exposed on the whole coast, we find the *Gryphæa incurva*, which so generally accompanies the inferior beds of Lias in the south of England, and *Belemnites acutus*, one of the earliest species of this family of cephalopods.

Henceforward to the town of Robin Hood's Bay, the cliffs are composed of the deeper Lias shale, in nearly level layers, surmounted by a variable covering of diluvial clay and pebbles. At low water the ranges of the strata are seen in grand curves sweeping across the whole extent of the bay. Beyond Baytown the cliffs increase in altitude, and a rapid declination of the strata towards the north is observed for the space of three miles. In consequence of this the deep shale sinks into the sea at little more than a mile from Baytown, the marlstone beds and ironstone beds above them have all dipped and disappeared in about two miles, and from there to Whitby the shore is kept by the Upper Lias Shale. So great is the depression, that between Hawsker bottoms and the place called High Whitby, the carbonaceous sandstones above the Lias stoop very nearly to the water. The solid beds of subcalcareous sandstone and ironstone (which constitute the Middle Lias series) form prominent scars where they sink into the sea; and their blocks, which are scattered at the foot of the cliffs, may be advantageously examined for starfishes and fossils. The ironstones are too thin to be of much value in presence of the richly ferruginous districts of Eskdale, Kettleness, Staithes, and Cleveland. There are more than a dozen distinct layers, making together about 7 feet in thickness, enclosed in shales about 70 feet thick*.

* This Marlstone and Ironstone series has been carefully measured by Mr. Simpson, who gives a total of 137 feet 11 inches—79 feet 3 inches for the ironstone, and 58 feet 8 inches for the Marlstone group. The ironstone beds are counted to sixteen, and their total thickness 7 feet 3 inches.

The highest point of the coast between Baytown and High Whitby (275 feet) is marked by the termination of the Dogger series. This irony sandstone, though at Blue Wick on the south of Robin Hood's Bay it is so rich in fossils, does not here contain a single shell, and is very thin; but the sandstones which succeed above contain the same plants as at the Peak. To convey an accurate idea of the succession of strata above the Lias and beneath the cap sandstone, the following details, at points marked in the section, will be found sufficient.

At the point where a road leads down the cliff from Hawsker bottoms we find the Lias shale covered by 50 feet of sandstone, coal, shale, and Dogger, arranged in the following order:—

Strong slaty gritstone. Shale. Strong slaty gritstone. Shale. Slaty sandstone. Coal-seam. Shale and gritstone, with marks of coal. Alternations of sandstone and shale. Irony bed or Dogger. Upper shale, 100 feet.

At a point nearer High Whitby the series of sandstones and shales is much more complicated; the following account was very carefully written on the spot:—

| | | ft. | in. |
|---|---|---|---|
| Loose blocks, sandstone, ironstone, shale, &c. | | 20 | 0 |
| Coal | | 0 | 8 |
| Grit, with vertical carbonaceous marks (coal-pipes) | | 4 | 0 |
| Irregular sandstone | | 5 | 0 |
| Shale and ironstone | | 12 | 0 |
| Sandstone | | 8 | 0 |
| Alternating shale and white sandstone-bands | | 9 | 0 |
| Sandstone | | 6 | 0 |
| Shale and thin sandstones | | 8 | 0 |
| Sandstone, slaty | | 2 | 6 |
| Coal and irony knots with shale | | 10 | 0 |
| White sandstone | | 2 | 0 |
| Shale | | 6 | 0 |
| Wedge-shaped grit rocks | from 20 to | 30 | 0 |
| White sandstone and coal, with vertical pipe-marks | 5 to | 20 | 0 |
| Shale | | 4 | 0 |
| White sandstone | | 2 | 0 |

| | ft. | in. |
|---|---|---|
| Shale | 4 | 0 |
| Layers of sandstone | 3 | 0 |
| Shale | 12 | 0 |
| Here a coal-adit enters into the face of the cliff. | | |
| White sandstone and plants | 2 | 0 |
| Irony Dogger bed | 2 | 0 |
| Alum-shale | 30 | 0 |

Passing inward at this point along a small beck, we find an old kiln, where lime was burnt from shelly beds, by estimation about 250 feet above the Lias. The section, as observed in 1824, was :—

| | ft. | in. |
|---|---|---|
| Shale, with ironstone | 8 | 0 |
| Limestone, with *Aviculæ* and other shells, and some balls of ironstone | 6 | 0 |
| Shale | 8 | 0 |
| Slaty sandstone and shale. | | |

At a point called High Whitby, 285 feet above high water, sandstone is upon the top, and ten or more alternations of shale and sandstones may be observed between it and the Lias. A sandstone bed, 74 feet below the summit of the cliff, is remarkable for containing a great number of cylindrical fossil plants, jointed across like canes, or rather like *Equiseta*, and furnished with a denticulated striated fringe or sheath at every joint. They are called by Mr. König *Oncylogonatum*, by M. Brongniart *Equisetum columnare*. They are situated vertically in the beds of sandstone, are broken off or imperfect above, and seldom reach to the upper surface of the bed; they are also broken off below, but commonly pass to the lower surface; and some of the lower joints nearest the roots are found in the subjacent bed of shale. These appearances have led to a probable conjecture that the plants are preserved in the place of their growth, that the shale served them for soil, and that they were buried by an influx of sand and water. A different hypothesis suggested itself formerly to myself, after seeing plants transported by inundations and floating down the streams in a perpendicular position, in consequence of the superior specific gravity of their roots. I am now

satisfied that in several cases on the coast, as at Gristhorpe, Cloughton, and Haiburn, *Equiseta* were prostrated and buried in abundance near to the spots where they formerly grew, and that here and there a few stems appear erect in the attitude of their marshy growth.

Proceeding from High Whitby, the cliff falls gradually toward the north, and at the same time the Lias rises to the height of 100 feet above the sea. From High Whitby northward, though the sandstones and shales vary much in thickness and colour, we may notice that the thin coal-seams are always most decisively marked, and most alluring to the adventurer, in the neighbourhood of the fossil plants which lie above the irony *Dogger* bed. These plants consist wholly of what are believed to have been allied to *Zamia*, and ferns of several genera. They lie in uneven, thin, white sandstones, alternating with black micaceous shale, and in ironstone, which is traversed by a white aluminous earth of the same nature as that previously noticed at White Nab, near Scarborough. The Dogger bed beneath them is a very singular layer, of inconstant appearance and varying substance. Sometimes, and indeed generally, it is a very irony nodular sandstone; but in other places, and particularly towards Whitby, it contains small pebbles of limestone, blende, small red ironstone, &c. Towards the bottom I have in some places seen it full of limestone pebbles (Lias ?), and under these a layer of large and small ironstone balls.

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### SALTWICK.

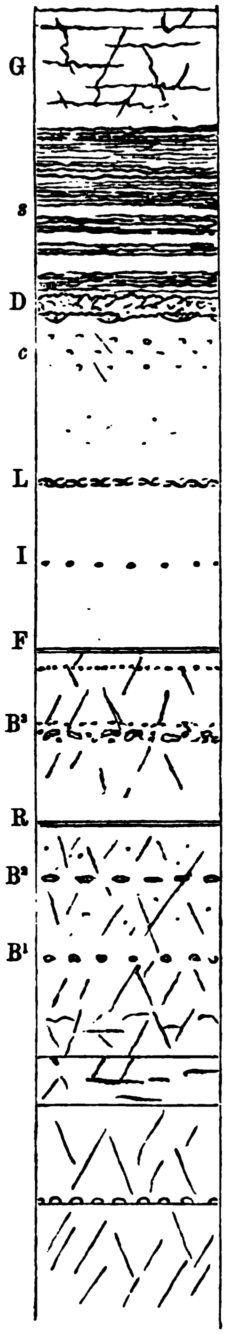
No part of the Yorkshire coast is more instructive in regard to the Upper Lias than the cliffs and scars of Saltwick, where the alum-works were formerly established. Here a bold promontory and a conspicuous island, formed of dark Lias, offer uncommon facilities for examining the whole section, and collecting from each layer of the rock its characteristic fossils, especially *Ammonites* and *Belemnites*. The Whitby Museum, under the care of Mr. Simpson, is particularly rich in these beautiful objects. The following is an epitome of my observations made at Salt-

wick, during many repeated visits in the course of half a century. The later examinations (1864-73) were mainly intended to determine the exact thicknesses of the beds and the distribution of *Belemnites* in the Upper Lias, from the "Dogger" downward to the "jet rock."


Saltwick, from the south.

In descending from the encircling cliffs to the great hollow in which the alum-works were situated, we pass over the thick cap rock of sandstone (G) and thinner alternations of sandstones and shales, with plant-remains (*s*), to the Dogger (D), and below this are able to trace, with no great difficulty, the uppermost bands of Lias with cement nodules, *Leda ovum*, and many Ammonites, and more easily much lower beds of Belemnites and Ammonites, till in the extreme scars which are prominent at low water, the jet rock and hard shales oppose a slowly yielding barrier against the sea.

The following is the section of all the beds here visible:—



| | | ft. | | |
|---|---|---|---|---|
| Cap grit ................ | G | | Irregularly stratified. | |
| Alternations of sandstone and shale ............ | *s* | | Occasional coal bands. | |
| DOGGER ................ | D | | Plants occasionally. Ferruginous. | |
| Cement nodules .......... | *c* | 34 | *Ammonites bifrons.* | *Belemnites Voltzii.* |
| Lumpy bed .............. | L | | | |
| Irregular nodules ........ | I | 34 | | |
| Flat bed ................ | F | | | |
| | | β ... 18 | | |
| Ball bed ................ | B³ | β | *Amm. ovatus.* | *Bel. vulgaris.* |
| | | ... 18 | | |
| Red bed ................ | R | | .............. | *Bel. subtenuis.* |
| Spheroidal balls .......... | B² | 32 | .............. | *Bel. tubularis.* |
| | | | .............. | *Bel. lævis.* |
| Pyritous balls ............ | B¹ | | *Amm. Mulgravius.* | |
| Jet bed.................. | | 50 | .............. | *Bel. tripartitus.* |
| Hard shale .............. | | | | |
| | | | *Amm. annulatus.* | |
| Soft shale................ | | 25 | .............. | *Bel. cylindricus.* |

The Ironstone series comes in below the soft shale.

G. The rocks lying over the Dogger are about 60 feet in thickness, the upper portion being mostly solid sandstone, the lower part (*s*) composed of alternating sandstones and shales, partly carbonaceous. *Zamiaceæ.*

D. The Dogger is of the composite mineral character usual in it about Whitby, with uneven surfaces, on which, and under which, appear excrescences usually more ferruginous than the mass. In the front of this cliff, some large irregularly spheroidal masses appear at intervals below what may be called the regular band. I observed no fossils in this rock, which altogether is 4 feet thick.

Grey alum-shale, the upper part a little sandy, with few or no fossils. At about 5 feet depth layers of small limestone nodules appear, and continue for about that space in sufficient plenty to be worked for the making of "cement" (*c*). Lower down the nodules are fewer, and admit a larger proportion of carbonate of iron, alumina, and silica. The shale is pyritous. In this part of the Lias *Ammonitæ* are in plenty, especially *A. communis* and *A. bifrons*; *Leda ovum* is in abundance; and *Belemnites Voltzii* and *B. vulgaris* may be collected on the scars toward Whitby by hundreds. Saurians are infrequent. The thickness varies from point to point, chiefly by changes in the upper part, which in some places admits sandy parts analogous to those of Blue Wick, and elsewhere loses all trace of these. My estimates give 34 feet for the thickness where greatest.

L. A conspicuous but very irregular band, occasionally swelling out into lumpy masses, more calcareous than most of the hard layers which occur below.

Dark alum-shale, 34 feet, with an irregular band of nodules. It is not rich in fossils. This appears to be in some cases the lowest bed worked for alum.

F. A thin bed of ironstone, somewhat remarkable for continuity, 4 inches thick.

Dark alum-shale, 16 or 18 feet thick, somewhat harder than the strata above. The fossils are chiefly Belemnites, of which a kind of bed is formed 3 feet below F. There is also a bed of Belemnites 1 foot from the bottom. Both are of limited extent. *Avicula.*

$B^3$. An irregular, frequently double band of subcalcareous nodules, large and small, lumpy, spheroidal, or flattened, ½ to 1 foot.

Dark firm shale, 16 or 18 feet thick, poor in fossils; Belemnites occur near the top and bottom.

R. Dark hard reddened shale-bed, occasionally changing to a ferruginous band, 3 to 6 inches.

Hard dark shales, 12 feet thick, containing *Belemnites subtenuis, Inoceramus dubius.*

$B^2$. Band of remarkable flattened spheroidal balls.

Hard dark shales, 20 feet thick, with numerous fossils, often pyritized. *Ammonites Mulgravius, Belemnites tubularis, Inoceramus dubius, Extracrinus.*

B[1]. Band of irregular balls, pyritized.

Grey hard shales, 20 feet.

Hard shale, 10 feet thick, with calcareous concretions, considerable portions of jet, *Belemnites tripartitus, Trigonellites*, &c., stands firm against the sea, but is broken up by workmen who seek the jet, which is here of good quality for manufacture, and undermined by the sea, which acts with energy on the shales below. The beds below are hardly seen at Saltwick, but are added to complete the section of Upper Lias.

Hard shales with large nodules in the upper part, 20 feet.

Soft shales, 20 or 30 feet thick, and containing *Belemnites cylindricus.*

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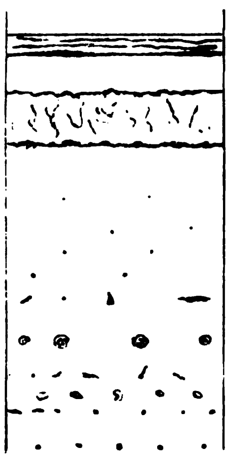
### ABBEY CLIFF.

Leaving the picturesque cliffs and hollows of Saltwick, we find on proceeding toward Whitby the Lias sink beneath a load of sandstones and shales, so as to bring the Dogger to the shore-line. Here an interesting junction appears, of which the following is a brief notice :—



| | ft. | in. | |
|---|---|---|---|
| | | | Shale, dark. |
| Shale …… | 1 | 0 | Plant-bed. |
| | 2 | 0 | Shale, pale pipy. |
| Dogger …… | 3 | 0 | Top ferruginous and undulated. Ironstone lumps on the bottom. |
| Shale with .. | 8 | 0 | Scattered ironstone lumps. |
| Shale with .. | …. | | *Belemnites Voltzii.* |
| | 2 | 0 | *Ammonites bifrons, A. crassus.* |
| | 2 | 0 | *Belemnites.* |
| | 1 | 0 | *Leda ovum, Amphidesma recurvum.* |
| | 1 | 0 | Band of nodules. |
| | 2 | 0 | Nodules. |

Some of the *Amphidesmata* appear in the attitude of life.

Near this a lenticular expansion of grey sandstone (S) appears immediately in contact with the Dogger (D), and yields many ferns and *Palæonia*—clearly a case of limited drift with false bedding. Above lies a

layer of dark shale and plants (P), and then a parallel band of sandstone (S′). The Dogger rests immediately on the Lias (L).

As we approach the harbour, the Lias rises to one third of the height of the cliff, and forms a very broad scar, richly filled in particular bands with Belemnites, *Ledæ*, and Ammonites. The scar and cliffs come suddenly to an end against a long line of fault directed north and south, by which the rocks are depressed under Whitby harbour and for the whole space westward as far as Sandsend, where a fault in a parallel direction lifts the same strata to about the same elevation.

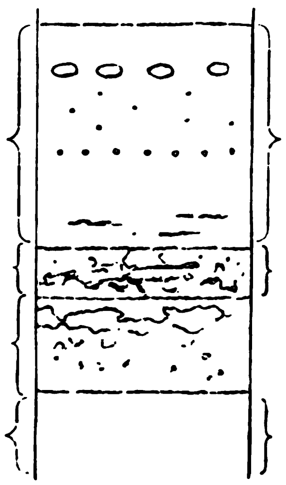
This great dislocation extends a considerable distance up the valley of the Esk. Its effects are very remarkable at the sea-side. On the east side of Whitby Harbour is a perishing cliff of the upper alum-shale, on an extended basis of dangerous scars; but on the west side of the water is a worn rock of sandstone, under a cover of glacial drift, overlooking a beach of sand. The exact amount of the depression occasioned by this fault cannot perhaps be determined; but I estimate it to be not less than 150 feet.

Between the cliff which supports Whitby Abbey, 185 feet above high water, and that where the Lyth alum-works are established, 190 feet, the strata are depressed by the before-mentioned fault, so that the Lias shale is almost wholly below the level of high water, and the cliffs are composed of sandstone and shale, covered by a very abundant deposit of diluvial clay and pebbles. The highest point between Upgang and Whitby is about 30 feet below the abbey; but generally the altitude is less than 100 feet. Where the road from Sandsend turns up toward Dunsley, and in a little watercourse, the Dogger, somewhat richer than usual in this part of the coast, appears over the Lias, of which only the uppermost portion shows itself above the sands. I found no fossils in either Dogger or Lias here. The clay-drift seen up this valley includes a parting of sands and pebbles; but a much greater thickness of more continuous sands ranges

along the front of the cliffs, especially on the west side of Upgang. It is an elevated old sand-beach, like what is now spread at the base of the cliff. In one place it is not less than 50 feet thick. I found no shells in this deposit.

At Sandsend one grand effect of the upthrow-fault is the elevation of the prominent cliff, which supports the alum-works, and is based on broad scars of harder Lias. Here, under a cap of 50 feet of sandstone and shale, with traces of plants, we find the Dogger, 6 feet thick, formed in two beds with a parting of irony shale, or what may be termed three beds, the middle one being composed of irregular irony nodules. Below the proper alum-shales, which are about 70 feet thick, the bold cliffs below present much the same series of hard shales with subcalcareous and ferruginous balls, and jet-beds with accompanying nodules, as at Saltwick. These cliffs, it is probable, furnished to the Romans the jet which was employed in ornaments, their station of "Dunum Sinus" (Dunsley Bay) being conveniently near. The layer of spheroidal balls noticed at Saltwick is even more remarkable here. The distribution of Belemnites and Ammonites in the shales and bands of nodules is the same as at Saltwick; pyrites occurs in the Mulgravian band, petroleum in the hard shales above the proper jet-bed; and large subcalcareous nodules and floors diversify the hard platy shales immediately below. According to my estimates the total thickness of the shales above the jet band is about 140 feet.

Sandsend.



Where a small valley divides the cliff beyond the Lyth alum-works, we observe rising from the water a portion of the shale, apparently more compact than the rest, and bearing much better the action of the sea. It is consequently much scooped into caves and fantastic projections, which are never seen in the softer shale above and below. On the cliff top the sandstone cap ranges uninterruptedly to Kettleness alum-works, and in the highest point is not less than 371 feet above high water. Here the sandstone, shale, and Dogger, above the Lias, are together 100 feet thick.

At Kettleness, from the sandstone rock just above the alum-works to the Lias scars beneath, the following section was constructed in 1828:—

| | | | feet. |
|---|---|---|---|
| *Carbonaceous series* . | Cap sandstone nearly . . . . . . . . . . . . . | | 50 |
| | Sandstone traversed by ochry veins . . | DOGGER . . | 4 |
| | Shale . . . . . . . . . . . . . | | |
| | Irony stone, in nodular masses and beds | | |
| *Upper Lias series* . . | Upper Lias shale, including the "mine" . . . . . | | 150 |
| | Hard shale, with layers of calcareous nodules . . . . | | 30 |
| | Soft shale . . . . . . . . . . . . . . . . | | 20 |
| *Middle Lias* . . . | Alternations of ironstone beds and shale, forming projecting scars . . . . . . . . . . . . . . . | | 20 |

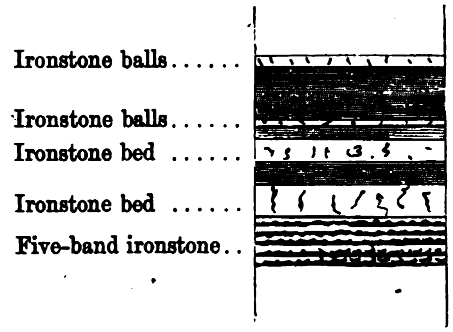
In subsequent visits the lower parts of this section were measured and remeasured, once in company with Dr. Cookson and Mr. Lee; in fact one never tires of studying the circumstances of the transition from the highly ferruginous beds and nodules below to the partially or completely calcareous layers which divide the Lias shales above.

The whole of the upper part of the Lias section corresponds with that at Sandsend and Saltwick, in the succession downwards through cement bands and lower parts of the alum-shale, the hard bands, jet rock, and shales below; and similar fossils lie in the same strata. The following were the groups finally adopted on the 25th of September, 1867:—

| | | | ft. | in. | | |
|---|---|---|---|---|---|---|
| Upper Lias | Hard shale and jet series . . | Hard shales with balls. | | | | |
| | | Jet rocks and balls. | | | | |
| | | Hard shales . . . . . . . . . . . . . | | | | *Belemnites cylindricus.* |
| | Soft shale series, 32 feet . . . | Soft shale . . | 15 | 0 | | |
| | | Platy shale . . | 1 | 0 | | |
| | | Shale and balls | 9 | 0 | Several scattered ball-courses. | |
| | | Platy shale . . | 1 | 0 | Long straight joints. | |
| | | Hard platy shale | 6 | 0 | One irregular ball-course at top, and one in the middle. | |
| Ironstone, 12 ft. 6 in., and shale, 9 feet 10 in. . | | Irregular balls . 8 in. to | 1 | 0 | *Amm. Hawskerensis* (*spinatus*). | |
| | | Skerry shale . . . . . | 2 | 6 | *Belemnites.* | |
| | | Shale . . . . . . . . | 3 | 6 | *Amm. Hawskerensis.* | |
| | | Ironstone balls . . . . | 0 | 6 | *Pecten sublævis*, Y. & B. | |
| | | Shale . . . . . . . . | 1 | 7 | *Bel. acuminatus.* | |
| | | Ironstone . . . . . . | 2 | 0 | | |
| | | Shale . . . . . . . . | 2 | 3 | *Pecten æquivalvis*, *Belemnites*, Wood. | |
| | | Ironstone, thick bed . . | 3 | 6 | *Amm. Hawskerensis.* | |
| | | Five-band series of ironstone, forming extensive scars . . . . . . | 5 | 6 | | |
| | | | 22 | 4 | | |

The ironstone and shale in the following section appear in their relative proportions :—

Kettleness.




Beyond Kettleness the cliffs for a considerable distance are much

encumbered with fallen débris, and the shore is less favourable for research than at some other points. On my last visit I found the diggings for "oil," which had been established on the shales connected with the jet rock, abandoned as unprofitable. The petroleum sought is usually in most quantity above the jet rock, specially so called; it is found in the joints of the rock, in the cells of Ammonites, and in other situations which seem on the whole suggestive of a process of distillation from carbonaceous compounds in the strata below. Something of the same kind may have happened in the coal strata of Butterley, where one of the beds is uncommonly rich in petroleum; and perhaps we may extend the hypothesis to the bitumen of the Derbyshire limestone and the retinasphalt of Highgate.

In the depth of the beautiful bay which expands between the promontory of Kettleness and the craggy cliffs of Runswick, the hard Lias shales sink to the shore, and are sufficiently bent to be entitled to the term of arched rocks, which were more conspicuous fifty years ago than they are now.

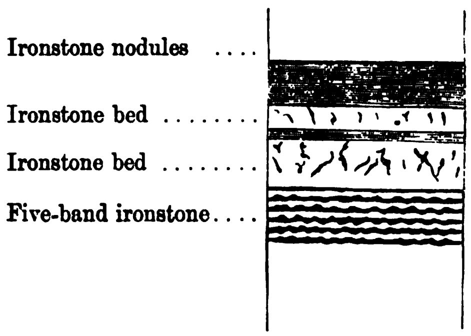
From this point to Runswick the beach is sandy, and the low and broken cliffs are mostly formed of thick masses of drifted clay and pebbles—which lie abundantly in the great hollow, much as they do in other such places along the coast, but appear only in thin and partial patches beyond the cliff-line.

Not far from the new hotel, situated above the romantically placed village of Runswick, the cliff is about 250 feet high, and the sandstone cap is seen upon the Upper Lias shale. The little valley or gully, which is here scooped in the steep descent, exhibits imperfect but, I think, satisfactory traces of a fault or dislocation, the strata being higher on the north side by about 40 feet.

The sandstone rocks there run out northward, and afterwards sweep round to a concavity called Rosedale Wyke, where ironworks were established (under some physical difficulties) at the edge of the sea a few years

since. The cliff is here 300 feet above the sea; and the section may be read with certainty to the water's edge. It corresponds in all essential points with those already noticed at Sandsend and Saltwick; but the Dogger is here a workable bed of iron-ore, and the bands of ironstone below the Upper Lias come again to day and were found useful in the furnaces at Newcastle-on-Tyne, to which in former years the Yorkshire ironstone was liberally if not very largely supplied.

Rosedale.




The ironstones worked at this interesting locality were thus recorded (September 16, 1867):—

Ironstones, 12 ft. 9 in., and shales, 6 ft. 3 in. . .

| | ft. | in. |
|---|---|---|
| Ironstone nodules . . . . . | 0 | 6 |
| Shale . . . . . . . . . . | 4 | 0 |
| Ironstone-bed . . . . . . | 2 | 3 |
| Shale . . . . . . . . . . | 1 | 0 |
| Ironstone . . . . . . . | 4 | 6 |
| Shale . . . . . . . . . . | 1 | 3 |
| Five (or even six) bands of ironstone, with thin partings of shale . . . . . . . . . | 5 | 6 |
| | 19 | 0 |

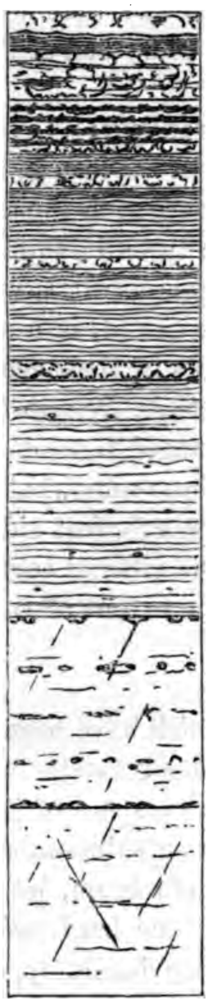
On comparison with the beds at Kettleness the total thickness of shale is less at Rosedale, but the ironstones nearly of the same thickness at both places.

Continuing our course along the shore, with frequent opportunities of examining the soft shales above the ironstone, and a constant capping of sandstone and Dogger rising to 300 and 320 feet, we cross a bay of some breadth, in which the strata are depressed till the point called Old Nab is

reached, where they rise to the west with a sensible inclination, and disclose one after the other every bed of the ironstone series.

The sandstone rocks pass inland; the hard shale forsakes the base and ascends the cliff; whilst from beneath it, first the soft shale appears, and afterwards the ironstone courses, in the same order as at Kettleness. A little bay not far from the tumuli exhibits a very pleasing scene at low water; for then the ironstone courses, which there spread out from the cliff, are visible over a wide extent, in a series of elegant flexures corresponding to slight variations of their declination. They contain multitudes of *Rhynchonellæ*, *Pectines*, *Belemnitæ*, wood, &c. Beyond they rise into the cliff, and may be traced towards Staithes, till their regularity is suddenly broken by an oblique somewhat complicated dislocation, which causes a depression on the north-west side of 15 feet. The section here exhibited consists, under the diluvial covering, of hard shale, soft shale, and ironstone beds; and the extent of the dislocation may be accurately determined.

The ironstone courses, which have been worked to some extent, may be examined with the greatest advantage in the cliffs and on the shore to the eastward of Staithes, for a space of three fourths of a mile, with the advantage of observing the superincumbent shales. These present hard shales with septaria and petroleum, jet rock and hard shale below it, and softer shales enclosing one hard bed, which elsewhere is ironstone. Then the ordinary ironstone bands appear. These, examined on five different occasions, have presented some local differences, partly laid bare in the workings, partly by waste of the coast. The following section, taken in 1867, gives a fair average view:—



| | | ft. | in. | |
|---|---|---|---|---|
| IRONSTONE SERIES | Hard-bed shale, 5 feet.. | 2 | 3 | Pecten æquivalvis. Myacites recurvus. |
| | Ironstone ............ | 1 | 6 | |
| | Shale .............. | 4 | 6 | |
| | Ironstone, with shale partings ... | .... | | *Pecten æquivalvis.* |
| | Five ironstone beds in shale ....., | 5 | 6 | *Pecten sublævis.* Belemnite beds. |
| | Shale .............. | 2 | 0 | |
| | Shelly ironstone ........................ | 1 | 3 to 2 ft. | Belemnite beds in and below this ironstone, with many shells and large smooth Pectens. |
| | Shale .............. | 7 | 0 | Few Belemnites. |
| | Ironstone ............ | 2 | 0 | |
| | Shale .............. | 10 | 0 | |
| | Ironstone ............ | 2 | 0 | |
| | Sandy shale, with five bands of scattered ironstone nodules ...... | 25 | 0 | *Cardium truncatum.* |
| | | .... | | Belemnites near the base. |
| MARLSTONE SERIES | Laminated sandstone and shale, with occasional ironstone-balls...... | 20 | 0 | |
| | Sandstone more solid, forming scar and part of cliff E. of Staithes harbour .......... | 20 | 0 | *Gryphæa.* |
| | | .... | | *Cardium truncatum.* |

In the above section the ironstone courses above the marlstone are in all 16 feet 6 inches thick, and the shales above and below them (including the sandy portions below) are 45 feet 6 inches (including the hard-bed shale above the thicker ironstones 50 feet 6 inches). Total 62 feet or 67 feet. The shales are in some places 8 or 10 feet thicker.

The ironstone beds, with their accompanying shales, which have now been noticed at Kettleness, Rosedale Wyke, and near Staithes, present in general, at or near the upper part, a considerable and on the whole

uniform thickness, though not equally divided:—12 feet 6 inches at Kettleness, 12 feet 9 inches at Rosedale, 12 feet 3 inches at Staithes; and lower down, seen at Staithes only, three separated beds, each from 1 to 2 feet in thickness, altogether 4 feet 3 inches to 5 feet. In the valley of the Eske, near Grosmont Bridge, two main beds of these ironstones occur, and have been worked from early times: the upper, or "*Pecten*-bed," 4 feet thick, including shale, corresponds to the 12-foot series of Staithes; the lower, or "*Avicula*-bed," 4 feet 6 inches thick, including shale, is represented by one of the lower beds at Staithes. They are separated in Eskdale by 31 feet of shale, including two courses of ironstone, 1 foot and ½ a foot thick. The Eston-Nab ironstone, 16 feet thick, corresponds to the 12 feet 3 inches at Staithes; and there is below it a bed to match the *Avicula*-bed or beds.

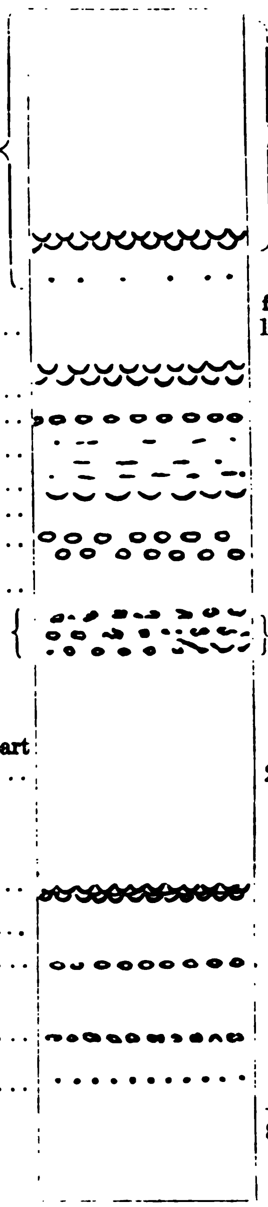
On arriving at Staithes we find in the cliffs on the opposite sides of this harbour admirable sections of strata; and it is with surprise we perceive that they are quite dissimilar. The signal-cliff on the east has a diluvial covering, and beneath it:—hard shale, irony and rugged, with great balls of ironstone; soft shale with a remarkable sulphurous line in it; and the ironstone series, consisting of layers of ironstone nodules and beds, alternating with shale. Quite at the base, and seen for a small area, are the upper sandy beds of the marlstone, as shown in the section, Plate XX. In Colborn Nab, on the west side, we find also a diluvial covering, but beneath it, in the front of the cliff, a series of alternations of shaly and sandy beds belonging to the marlstone, in some of which is an indescribable profusion of fossils, especially *Cardium truncatum*, *Pectines*, and *Dentalia*; and at the bottom the Lower Lias shale, with layers of ironstone nodules.

On the eastern side, at high water the sea rises to about the top of the marlstone; on the western side it is at or below the bottom of that rock,—a difference which, if attributed to a fault, would require an upthrow to the west of about 70 feet. In my early examinations this was the view adopted; but the estimate of elevation was in excess. After repeated visits and additional measurements, I conclude that part of the difference

of level is due to the westward rise of the beds, which continues from Colborn Nab toward Boulby, and part to a fault ranging up the Staithes valley. I suppose the marlstone series to be 70 feet thick.

The picturesque cliffs of Staithes offer most advantageous situations for collecting the fossils of the Yorkshire ironstone, marlstone, and part of the Lower Lias. Excepting the middle part of the marlstone in the front of the cliffs of Colborn and Boulby, it is possible to measure almost every bed in the series, and to determine exactly the concomitant fossils. Of all these fossils Belemnites are the most frequent, and, not excepting Ammonites, they are as characteristically different in the different strata as any. *Belemnites cylindricus* occurs in the soft shale above the ironstones, *B. breviformis* and *B. rudis* in the ironstones, *B. numismalis* in the marlstone, *B. pollex* in the Lower Lias immediately below the marlstone. So of Ammonites—*A. annulatus* above the ironstone, *A. spinatus* in the ironstone, *A. margaritatus* in the marlstone, *A. maculatus* below it. Dimyarian Mollusks are too few to be used with safety, though *Cardium truncatum* be almost strictly of the marlstone age; but Monomyarian Conchifers afford in the upper ironstones *Pecten æquivalvis*, in the lower *Avicula cygnipes*, in the marlstone *Gryphæa depressa*, and below it *Modiola scalprum*. All these may be studied *in situ* at Staithes.

The subjoined section shows the series of beds easily traceable in the lower parts of the cliffs round which the path (if it may be so-called) winds in passing Colborn Nab, and going westward :—



| | ft. | in. | |
|---|---|---|---|
| Lower parts of the marlstone series in Colborn Nab | 30 ft. | | Thin sandstones and shales, with thicker and harder beds more or less banded, with *Pectines*, *Cardia*, *Gryphææ*, *Dentalia*, *Belemnitæ*, &c. |
| | | | *Gryphæa*, *Serpula*, *Belemnites*, &c. |
| Grey shaly sandstone | 12 | 0 | |
| | 2 | 0 | *Gryphæa* band. |
| Sandy sandstone | 6 | 0 | *Ammonites spinatus*. |
| Ironstone | 0 | 4 | |
| Shaly shale | 8 | 0 | Three layers of *Gryphæa*. |
| Ironstone | | | *Belemnites*, *Gryphæa*. |
| Shaly sandstone | 4 | 0 | |
| Ironstones and shale | 2 | 0 | *Gryphæa*. |
| Shaly sandstone | 6 | 0 | |
| Ironstones and shale | 4 | 0 | *Amm. margaritatus*. |
| Grey shale, the lower part hard, prominent | 25 | 0 | *Belemnites pollex*, *Modiola scalprum*. |
| Ironstone | | | |
| Shale | 8 | 0 | |
| Ironstone | | | |
| | 8 | 0 | |
| Ironstone | | | |
| | 4 | 0 | |
| Shale | | | Spherical balls 3 inches in diam.* |
| | 89 | 4 | Thickness below Marlstone. |

The dislocation at Staithes is the last which I shall have occasion to notice; for though the declination of the strata in the lofty cliffs

* These have been picked up as cannon-balls! The layers of shale continue plane up to the spherical surface.

beyond is variable and subject to flexures, there is no fault or break whatever. Another general fact is, that the deeper shale, which showed itself at the foot of Colborn Nab, is uniformly found in the lowest parts of the cliff, from that point to Saltburn. It rises from Colborn Nab towards the precipices of Boulby, and there attains an elevation of about 100 feet. It encloses nodules of ironstone in rather distant layers, and many fossils, as *Belemnites, Plicatula, Pecten, Gryphæa*, wood, &c.: from this height it sinks down to almost the level of the sea at the Lofthouse boiling-houses, and so continues across the bay at Skinningrave; but further on it ascends, and in the loftiest point of Huntcliff seems to be 180 feet above high water. It falls again towards Saltburn, and terminates against the diluvial cliffs there at an altitude of about 50 feet. It appears, then, that nowhere on this part of the coast is the lower shale disclosed in greater thickness than 200 feet, whereas, in consequence of the great fault at the Peak, 300 feet are there seen in the cliff. Toward Staithes the low-water scars of this shale are rendered interesting by the singular appearance of the sandstone and ironstone masses, which look like mushrooms on little pedicles of shale. They have evidently protected the shale beneath them from wasting.

The sandy conchiferous marlstone beds, which in Colborn Nab cover the Lower Lias shale, are seen rising with it, and contributing to swell the altitude of Boulby and Rockcliff. The lower part of this series is generally the most solid, and projects in broad compact floors above the Lias. On the surface of such beds lie innumerable multitudes of oysters, *Dentalia, Pectines, Cardium truncatum, Avicula inæquivalvis*, and, about Staithes, beautiful fossil starfishes of the genus *Ophioderma*. The marlstone may be well examined on the shore from the boiling-houses of the Rockcliff works to Skinningrave; for there the beds come near to the level of the sea: but along the whole coast fallen masses of this rock abound, and will richly reward the researches of the industrious collector. Above lie the ironstone courses which were noticed on the side of Staithes harbour. These range uninterruptedly across the front of Boulby and Rockcliff, and again show themselves in the highest part of Huntcliff. Still higher, in Boulby and Rockcliff, we trace the soft shales and hard shales with limestone nodules which were observed at Kettleness and

near Staithes; on these lies the great bed of aluminous shale, which is so extensively worked; and the whole is surmounted by the sandstone cap rock.

In Boulby cliffs, then, we have nearly the whole series of Lias beds which appear on the coast, and are enabled to verify in one almost vertical face the general section presented (p. 26), except the lowest part. At Boulby the ironstone has been worked; both here and at the western end of the great cliff, alum-works have exposed all the Upper Lias, and yielded abundantly fossils like those of Saltwick, with similar Ichthyosaurian and Plesiosaurian remains. Near the top of Rockcliff the Dogger comes in; at Huntcliff it crowns an interior hill; in neither place is it worth working for iron. At Skinningrave, where the strata bend downward, the ironstone sinks to the level of the little rivulet, and is worked, with a thickness of 11 feet. It was cut through of about equal thickness in making the railway-curve round the front of Huntcliff, and is found spreading far inland to Skelton and Upleatham, Eston, Belmont, Kildale, and the Cleveland Hills.

Huntcliff has the advantage of showing a greater thickness of the lower shale than Rockcliff, with *Plicatulæ*, *Belemnitæ*, and *Ammonitæ*; but its series is very incomplete above, the upper shale having retired inland beneath the beacon, where the Dogger is found. There is hardly any diluvial matter observable on the high summit of Rockcliff; but it occupies a large portion of the lower cliffs near Skinningrave, is in considerable quantity on Huntcliff, and gradually thickens toward Saltburn, till at length the Lias formation is abruptly truncated, and the whole cliff is diluvial. Henceforward to the Tees no regular stratum appears in any cliff beneath the diluvium; but opposite Redcar, at low water, the lower shale with characteristic fossils stands up in bare hard rocks.

# CHAPTER XII.

## DILUVIUM.

HAVING now brought to a close the descriptions of the strata as they appear in the Yorkshire coast, it remains to consider in a general manner some of the questions which presented themselves in the course of the survey, and could not be fairly met by detached inferences suggested by separate data in different localities. One of these questions regards the "Diluvium" or "Drift," which is seen at intervals on the whole line of coast from the Humber to the Tees. The origin of the materials, the agency of their distribution, their geological date, and relation to actual and former features of physical geography and climate, have been already noticed here and there, but may now be considered in a more general view.

It will be seen by the foregoing descriptions that the supracretaceous deposits which are known in Holderness, and present themselves on the coast, constitute altogether this general series:—

| | |
|---|---|
| Lacustrine Marls | Lacustrine marls.<br>Gravel deposit.<br>Lacustrine marls. |
| Upper Gravels | Gravel, sand, &c. |
| Laminated Clays and Sands | "Warp"-beds. |
| Upper Boulder-clay south of Bridlington | Brown clays with fragments.<br>Sands and gravels (irregular).<br>Brown clays with fragments. |
| Middle Gravels | Gravel, sand, &c. |
| Lower Boulder-clay | Blue clay with chalk and flint, and fragments of distant rocks. |

| | |
|---|---|
| "Bridlington Crag," of undetermined age . . . . . . . | A limited sandy mass unconformed to the Boulder-clay above it, and rich in marine shells, mostly of existing species, and indicating a cold climate*. |
| Basement-bed or Lower Gravels . | Fragments of chalk and flint with a few boulders of distant origin. |

An ingenious effort has been made by Mr. Searles V. Wood and Mr. Rome to correlate these drift-beds (in which they include the "Bridlington Crag") with other extensive deposits of glacial and postglacial date in the Midland and South-eastern tracts of England. They class the Holderness deposits in the following series:—

*g.* Lacustrine marls with *Cyclas.*
*f'.* Gravel, principally chalk fragments.
*f.* Sands and gravel (at Hornsea lacustrine marls).
*e.* Hessle clay.
*d.* Hessle gravel.
*c.* Purple clay.
*b.* Sand and gravel, including the "Bridlington Crag."
*a.* Blue clay, supposed to be contemporary with or a continuation of the chalky basement-bed as viewed by me.

The relation of these three clays, *a, c, e* (all glacial), to the boulder-clays of the country further south, may be thus stated according to the view of the authors named:—

| Yorkshire. | Midland and South of England. |
|---|---|
| Hessle clay. | |
| Purple clay. | |
| Blue clay . . . . . . . . | Upper glacial clay. |
| ——— . . . . . . . . | Middle glacial deposits. |
| ——— . . . . . . . . | Lower glacial clay. |

—a very remarkable result, leading, if confirmed, to important inferences in regard to the conditions of area and depth of ocean at different epochs of the Glacial period.

* This inference is on the sufficient authority of the late S. P. Woodward. I obtained a series of the shells in 1835.

The apparent confusion and irregularity of the glacial accumulations, their various and seemingly accidental composition and geographical distribution, have occasioned much difference of opinion as to the conditions of their deposition. They have been explained as the consequence of sudden inundations on land, or violent deluges of the sea; glaciers have pushed them; icebergs have floated them; the level of the sea has been altered to suit them; and the temperature of circumpolar regions has been intensified to permit of the occurrence of almost universal overland ice.

This divergence of opinion, this activity of discussion, not to be wondered at in regard to one of the hardest as well as most important geological problems, has brought out the peculiarities of the case, and dismissed some vain speculations. The Yorkshire drift is allowed to be a marine deposit. It required a long period of time for its accumulation, and two concurrent and seemingly inconsistent effects in water. The pure clay was deposited in deep or at least quiet water; the stony contents of the clay require watery movement. Some of the stones are too large to have been transported by ordinary *sea-currents* in any direction; and no possible current of this kind could bring stones of such kinds and in such numbers to mix with such clay. But they might be floated on ice and dropped through muddy water on the growing sea-bed.

The clay offers a uniform basis, often with little or no real stratification, and without contemporaneous shells of any kind; in other situations such clays admit of warp-like sediments distinctly laminated, and beds of unmoved marine clays or sands, with shells of bivalve mollusks in the very place and attitude of life (Cromer coast, Yorkshire coast).

Through considerable thicknesses the clay is usually filled with scattered fragments of stone, with many fossil shells, derived from rocks whose site can be clearly recognized, so as to prove the wasting of certain tracts of land in Yorkshire, Westmoreland, and Northumberland, previously to the aggregation of the whole drifted mass.

Here and there pebbles, usually of small size, and stones and fossils more or less worn, lie in short insulated patches, on long bands in the clay, or rudely alternating with it, especially in the upper part, where these alternations are often followed by a great thickness of gravel above, having the ordinary composition and structure of a beach, imparted by fluctuations of the sea or currents of fresh water. In the clay, but more commonly in the gravel, remains of land animals occur broken, scattered, and rounded.

The shape of the pebbles is often ellipsoidal, with three axes of unequal length. A spherical pebble is rarely seen; but forms oblately spheroidal, with the short polar axis transverse to the original lamination, may be chosen among fragments of liassic shale and laminated sandstone. Egg-shaped pebbles may be found, small in quartz, large in aphanite, porphyry, and granite; and in general the smaller the mass, and the more uniform its composition, the greater is the approach to sphericity. In some cases there is an evident though partial arrangement of the stones, such that thin broad stones rest on their flat surfaces; and others lie in planes parallel to the laminæ of warp or sand. But few, comparatively, of the fragments are striated; some bear striæ in various directions.

The circumstances which have been mentioned contrast obviously with every thing known of the ordinary strata of every geological age. If we seek among these for examples of least difference, we shall find the most favourable instances in the Old Red, Permian, and Triassic deposits—the red brecciated conglomerates. Taking the first example, we remark in Perthshire, Cumberland, and Westmoreland, indeed, a variety of imbedded stones; but they are derived from a limited drainage; while the boulder-clays contain abundantly fragments derived from rocks beyond (far beyond) the limits of the drainage in which they lie. How came they hither? what has caused the peculiarities of their accumulation?

The problem or "question," as it may fairly be called, of the Boulder-

clay, and its associated gravels and sands, is not easy of solution, though it admits of clear enunciation. Given various points of departure, one or more points of arrival, and the condition and association of the blocks found there, required the agency of transport, the track by which they came, and the condition of the land and sea at the time. In examining this apparently Ariadnean labyrinth, we shall find the benefit of following some hypothetical thread.

Let us inquire into one case, involving considerable distance and a varied aspect of country, but without doubt as to the origin of the blocks, and with some sure indication of their course. Such a case is furnished by the blocks of granite which have quitted Shapfells in Westmoreland, and now rest on the high ground about Flamborough Head, Scarborough, and Whitby.

In the present arrangement of the land and sea, transport by any natural force of the Shap blocks to the hills of East Yorkshire is of course impossible. Let us examine, in the first place, the hypothesis that in the remote time immediately preceding the removal of the blocks, the land-surface might be such as to allow of water-currents descending with force from the north-west. To this the reply is conclusive: the deep dale of the Eden is an ancient, even a Mesozoic valley, with a lofty unbroken barrier on the east; and this quite forbids the supposition.

Next let us assume a change of climate, and fill this deep vale of the Eden and the broad vale of York with ice, so as to allow of the passage of a glacier from the Westmoreland mountains over a sort of inclined plane, on which blocks might rest, and on the melting of this ice, be distributed. By reference to the map, p. 9, it will be seen that such ice-movement must have been unlike any then known; for it supposes a radiation over a vast area, from one small mountain which sent its detritus through one gap in a chain of hills. Moreover, by such an operation only one class of blocks is accounted for; they ought to be in groups but little mixed with other stones, while in fact the mixture of stones of different sorts brought in different directions is what requires explanation.

Briefly, it must be allowed that no explanation can be had except by employing the hypothesis of a change in the physical condition of the whole region, such as to bring into action some other forces than surface-currents or ice moving on land. This can only mean extensive change of level of the land and sea, and the movement of water at considerable depths over the land.

Suppose such a change of relative level, the sea reaching the height of Shapfell (under 1500 feet); the climate arctic; extensive glaciation among the lake mountains; ice-sheets pushed into the sea as in Spitzbergen; these gathering blocks, breaking off in bergs, and floating with the currents as from Greenland. There would be a distribution of lake-mountain rocks northward and eastward, and to some extent southward.

Suppose the arctic character of climate to continue, but the sea to subside, no more Shap blocks would pass over Stainmoor; of those which had passed over, many would be carried to greater and greater distances and lower and lower levels, as in fact we find them.

After the currents had ceased to flow through what may be called the Straits of Stainmoor and to the southward, they might still sweep round the northern end of the Penine Chain, and drift along the ice-bound coast with mountain limestone, aphanite, magnesian limestone, and Lias, to the southward, together with some spoils from the northern parts of the lake-mountains, from the Scottish ridges and sea-coast. Possibly the Scandinavian slopes may have contributed to increase the mass; and the sea continually sinking, and followed in its retreat by sheets of land-ice, we should have as a final result the disordered accumulations, for which, except by such combinations as are here suggested, there seems to be no satisfactory explanation. In this view the "diluvial" masses are parts of abandoned sea-shore beds, disturbed by pressure of sheets of ice from the land.

The following list of Mammalian remains found in Pleistocene deposits in Yorkshire may be useful:—

| | |
|---|---|
| CARNIVORA . . . . . | *Felis spelæa* (Cave-Lion). In lacustrine clay, Bielbecks. |
| | *Canis lupus* (Wolf). In lacustrine clay, Bielbecks. |
| | *Ursus spelæus* (Bear). Near Clitheroe. |
| PERISSODACTYLA . . . . | *Equus fossilis* (Horse). (Small) below boulder-clay, Hessle; in gravel, near York. (Large) in lacustrine clay, Bielbecks. |
| PROBOSCIDEA . . . . . | **Elephas primigenius* (Mammoth). In glacial gravel, Atwick and Brandsburton; in valley-gravel, Middleton-on-the-Wold; below Boulder-clay, at Hessle; in Boulder-clay, at Sandley Meer, Whitby, &c. |
| ARTIODACTYLA . . . . | *Hippopotamus major*. In gravel, at Overton, near York; in river-sediments, Leeds. |
| | *Rhinoceros tichorhinus*. In lacustrine clay, Bielbecks. |
| RUMINANTIA . . . . . | *Bos primigenius*. In valley-gravel, York &c. |
| | **Bison antiquus*. In lacustrine clay, Bielbecks. |
| | *Cervus elaphus*. In valley-gravels and lacustrine sediments, Holderness, Vale of York, &c. |
| | *—— *megaceros*. In lacustrine clay, Skipsea, and near Wetherby. |

It appears that two remarkable animals, viz. *Bison antiquus* and *Cervus megaceros*, which occur in lacustrine clays, are not yet reported from Kirkdale Cave; and, as far as is known, the same applies to the mammoth. There is, however, the general agreement which was to be expected between pleistocene deposits removed in point of time some thousands of years from our own days.

The animals which occupied or were dragged as captives into Kirkdale Cave belonged to the species in the following list, which is almost identical with that given by Dr. Buckland in the 'Reliquiæ Diluvianæ.' No trace of man or his works:—

MAMMALIA.

| | |
|---|---|
| CARNIVORA . . . . | *Felis spelæa* (Cave-Lion). |
| | *Hyæna spelæa* (Cave-Hyæna). |
| | *Ursus spelæus* (Cave-Bear†). |

† Mr. Dawkins adds *U. arctos* (the Brown Bear) and *U. ferox* (the Grizzly Bear); their bones are very similar.

| | |
|---|---|
| | *Canis lupus* (Wolf). |
| | —— *vulpes* (Fox). |
| | *Putorius ermineus* (Weasel) *. |
| | *Lutra vulgaris* (Otter), according to Dawkins. |
| RODENTIA . . . . . | *Lepus cuniculus* (Rabbit). |
| | —— *timidus* (Hare). |
| | *Arvicola amphibia* (Water-Rat or Vole) †. |
| | —— *agrestis* (Field-Vole). |
| | *Mus sylvaticus* (Field-Mouse). |
| PERISSODACTYLA . . . | *Equus fossilis* (Horse). |
| | *Rhinoceros hemitœchus* ‡, Falconer. |
| PROBOSCIDEA . . . . | *Elephas antiquus.* |
| ARTIODACTYLA . . . | *Hippopotamus major.* |
| RUMINANTIA . . . . | *Bos primigenius* (the Urus). |
| | *Bison priscus* (the Aurochs). |
| | *Cervus elaphus* (Stag). |
| | —— *Bucklandi.* |
| | —— *Tarandus* (Reindeer). |
| | —— *megaceros* (Irish Elk). |
| AVES § . . . . . . | *Corvus corax* (Raven). |
| | *Alauda arvensis* (Lark). |
| | *Columba* ——? (Pigeon). |
| | *Scolopax gallinago*? (Snipe). |
| | *Anas sponsa*? (Summer Duck). |

What, then, is the geological date of the occupation of Kirkdale Cave? It will be observed that the analogies which its contents offer to pleistocene deposits in the open air, refer to such a case as that of Bielbecks, where glacial drift overlies the bones, and where these belong to animals certainly contemporary with the shelly substrata, and older than other lacustrine deposits which are superposed on the drift and contain animals which lived at that later time. The intermediate truly glacial deposits

* *Putorius vulgaris* (Polecat) is quoted as from Kirkdale Cave by Prof. Morris (Catal. p. 361, ed. 2).

† Mr. Dawkins refers the fossils to *Arvicola riparia* (Bank-Vole).

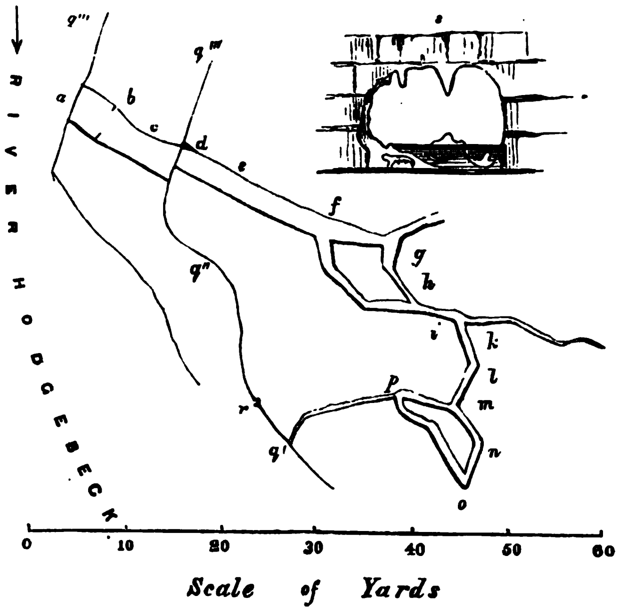
‡ This determination depends on a young tooth in the Oxford Museum.

§ In a former edition I added to these birds the Partridge, from observations made at York by Mr. Salmond; but as yet I have not been able to confirm this determination.

contain bones of the earlier types, but always in scattered fragments and generally rolled. Thus three periods, all pleistocene, are marked by characteristic features, and may be thus represented :—

| 1st. *Preglacial Land.* | 2nd. *Glacial Waters, rising and falling.* | 3rd. *Postglacial Land.* |
| --- | --- | --- |
| Lion, Hyæna, Mammoth, Rhinoceros, &c., living on a dry land-surface &c. | Remains of animals of the first period scattered, and often worn, lying in gravel, clay, &c., which were deposited under water. | No great Carnivora, no great Pachydermata living, the terrestrial surface abounding in Cervine and Bovine quadrupeds. |

*Plan of Kirkdale Cave* (1821–22), *from the original drawing by W. Salmond, F.G.S., in the possession of Professor Phillips.*




*a.* Supposed original opening. *b.* Opening as it appeared in 1821 (11 feet wide, 4 feet high). *c.* Width 9 feet, height 4 feet 6 inches. *d.* The floor rises 1 foot 6 inches, and the width contracts from 11 to 6 feet. *e.* Width 6 feet, height 3 feet. *f.* Width 6 feet, height 1 foot 8 inches. *g.* Width 7 feet, height 4 feet. *h.* Width 2 feet 5 inches, height 1 foot 4 inches. *i.* "Chamber," width 2 feet 2 inches, height 14 feet (Dr. Buckland gives 1 foot 4 inches). *k.* Height 3 feet. *l.* Width 3 feet, height 2 feet 7 inches. *m.* Height 3 feet. *n.* Width 2 feet 6 inches, height 2 feet 6 inches. *o.* Width 2 feet: here was found a tooth of *Elephas antiquus.* *p.* Here a fissure from a point which is marked as "chamber," 11 feet high. *q′.* A small opening on the face of the rock, *q″*, *q‴* continuation of the quarry face. *r.* Hole, connected with a fissure.

The sketch *s* shows a cross section of the Cave.

That Kirkdale Cave was occupied in the preglacial condition of the land which is now Yorkshire was my earliest opinion, and seems still to be the most probable inference in the present state of our knowledge.

The valley which passes down Kirkdale must have been below the level of the cave in preglacial times—must have been excavated, though perhaps not to its present depth, which is 30 or 40 feet below the floor of the nearly level ossiferous tunnel. There is no reason to think it was not in a good degree dug out by the river. There is plenty of proof of other valleys of smaller extent being scooped out of the glacial drift by rivulets now running to the sea. These circumstances agree with the inferences from the study of the mammalian remains; and so, finally, three Pleistocene ages rise clearly before us, for which at present the titles which were suggested twenty years since* seem to be applicable and convenient, and have indeed been pretty generally adopted.

The Yorkshire cliffs which stand above the sea are a proof of the great antiquity of the level and limits of the actual German Ocean; for they have to the waves which are always warring against them the same relation that the crowning rock of a cascade has to the mechanical power of the stream which after falling washes its base. Both yield, though slowly, to the never-wearied undermining effect of the water; and no one who regards the real but almost insensible destruction of the firm Flamborough Chalk, need hesitate to allow for the production of its cliffs of 150 to 300 feet a long term of centuries. But the same long period would allow of a far greater *horizontal* waste of the weaker barrier of sand, gravel, and clay which is all that Holderness offers to the enemy. There very long periods of forest-growth may have preceded the settlements of the Parisii, and have come down even to the date of Agricola.

It may be true, as Mr. de la Pryme and other writers appear to think, that in the destruction of the inland forests of Hatfield and Thorne the hand of man is traceable, and that fire and the axe have accelerated the fall of the innumerable oaks there buried. This may be correct: but it

* Rivers, Mountains, and Sea-coast of Yorkshire, ed. 1, p. 183, 1853.

is not the general truth which fits the countless instances round the shores of the German Ocean; for these, taken generally, appeal to natural causes for the successive growth of different kinds of trees and the accumulation of turf-moors round them, and to the force of south-west winds, the effect of river-floods, and the advance of the sea for the extinction of the lowland forests.

Extending our view, in the ancient connexion of Scotland and Scandinavia by the continuation of the primary strata, which geologists have long regarded as probable, which the particular phenomena of Yorkshire geology specially suggested, and which botanical philosophy confirms and brings down to the preglacial period*, we may find the explanation of many difficulties. When the Scottish and Scandinavian chains were connected (before the Straits of Dover existed), the German Ocean may have been cut off from the warm feeders of the Atlantic, chilled by the influx of snow-fed rivers, and occasionally covered by icebergs broken off from glaciers in the fiords of the north and bearing fragments of rocks indicative of their origin.

When that northern land had sunk, a milder climate and more purely oceanic and arctic shells would enter with the rushing of the newly admitted tide, a greater depression of water-level would ensue, accompanied by enormous wash of the limited shores; then would come into sight the cliffs of the "tabular hills" near Scarborough and Thirsk, and finally the promontories of Boulby, the Peak, Flamborough Head, and Dimlington heights (or rather points something further seaward than these now stand). Holderness, and the vales of York and Pickering would then appear or reappear above the waves; forests haunted by the stag might grow even in deep hollows of the surface, which were removed from the pernicious influence of the tide and the east wind; these would be destroyed as the waste of the coast terminated their immunity, and in particular places would be buried under alluvial sediments, sometimes brought by the rivers, sometimes accumulated by surface-drainings in lakes such as yet exist in Holderness.

* See 'Rivers, Mountains, and Sea-coast of Yorkshire,' 1853.

# CHAPTER XIII.

## ECONOMIC GEOLOGY.

"To specify the most valuable mineral productions, to determine their relative importance and aptitude for economical uses, and to fix the principles which should guide adventurers in quest of them, is the pleasing duty of a practical geologist. No part of England enjoys greater advantages from the variety and value of its subterranean treasures than Yorkshire. Its rich mines of iron, lead, and zinc, its vast collieries and innumerable quarries of building-stone, flagstone, slate, and limestone are productive of increasing wealth and convenience at home, and of considerable benefit to the empire at large. The eastern part of the county, though less distinguished in this respect than the western, contains many useful minerals, and, besides supporting a very important inland commerce, is capable of furnishing large supplies for exportation." [This paragraph was written in 1828.]

One familiar with the condition of East Yorkshire toward the beginning of the century finds on returning to it no great change in the aspect of nature, but much cause for surprise in the altered circumstances of human occupation. Then Scarborough was not the "queen of northern watering-places," and few were the summer visitors who appeared at Redcar, Filey, or Bridlington Quay. Whitby, though famous for fossils, ships, and arctic whale-fishers, was difficult of access and deficient of accommodation. One road across the wild moors connected this prosperous port and this Scandinavian part of Yorkshire with the old Roman capital of the north, and invited "H.M. Mail" to descend the perilous steep of Sleights Bank to the woody and secluded dale of the Eske. Pack-horses and carts were the means of conveyance; "waggon parties" occasionally forced their way to neighbouring waterfalls; but only a few bold horsemen brought home news of the English lakes.

Gradually, by the influence of railways, the whole coast has been transformed, and is in course of undergoing further change, until Staithes and Runswick and Robin Hood's Bay shall become as frequented as Saltburn and Filey, and Hornsea and Withernsea and the stormy sea-border of Yorkshire be as populous with villas as ever was the quiet bay of Naples and Puteoli in the days of Pliny. And hardly more wonderful in that glorious bay is the awakening fire of Vesuvius than the mighty blaze of many furnaces now planted along the banks of the Tees, where only a quarter of a century since not one was lighted, and where still, but for the railways, none would exist.

In the beginning of the century a curious observer might pause in Bilsdale or Rosedale or Eskdale to consider the heaps of scoria in places where once small "bloomeries," the primitive earth-furnaces furnished a sparse population with the small quantity of iron required for a few ploughs and hoes, or a few spear-heads and bill-hooks, hammers, and nails. Hundreds of years had passed since those small fires were burning; and though the country, the whole country lying north of the Vale of Pickering, almost every where contained iron in beds and nodules of various quality, the scarcity of wood and coal and the want of roads prevented even imprudence from trying to revive a lost though not quite forgotten industry,—not forgotten, because still, gathered from the coast, or selected from the alum-works, a few thousand tons of good ironstone were carried in small coasting-vessels to the only mart then accessible, the centre of the northern coal-trade, Newcastle-upon-Tyne.

To supplement this scanty supply, which, however, was welcome in a coal-field not so rich in ironstone as some others, a mine was established near Grosmont Bridge: a level was driven; and two separate beds of good ironstone were worked to the extent of some 20,000 tons in a year, and shipped from Whitby. These beds (the upper locally known as the "Pecten" bed, 4 feet thick, the lower as the "Avicula" bed, 3 feet thick) correspond in geological position and general characters with the now better-known ironstone beds of Kettleness, Staithes, and the Cleveland Hills. These ironstones, below the alum-shale and above the marlstone,

became known to science, by the publications of Dr. Young and Mr. Bird and my own volumes, from forty to fifty years ago; and had there been railways, it would not have been left to the practical men of our days to pierce into the heart of Eston Nab, extract millions of tons of iron-ore, and build hundreds of furnaces in Cleveland.

When the observing eyes of Mr. Vaughan were first directed to these hills, he was, we are informed, quite unaware even that the existence of iron had been recorded in this part of Yorkshire. It does not appear that he ever considered the matter in a scientific point of view. But it is easy to understand how one accustomed to the ironworks of South Wales, and standing on the brow of a Cleveland hill full of iron-ore, within a few miles of the coal-field of Durham, would feel inspired by the great idea of planting a new Merthyr halfway between the iron and the coal on the banks of the Tees, within reach of the North-of-England Railway. If science be to blame for not having more loudly invited attention to the unequalled store of mineral wealth existing in these hills, practice must not be exonerated from the charge of indifference to geological discoveries which had been clearly announced. Each, in fact, did its appropriate work, perhaps too exclusively; but the railway and the locomotive have brought them into harmonious cooperation in one of the grandest and most prosperous enterprises of our time.

Iron-ores of more or less value occur in all parts of the oolitic and liassic system of Yorkshire, in regular beds or nodules, or irregular patches. Taken in vertical order, and including some calcareo-ferruginous septaria, the following is, so far as I know, a complete list. The numbering is from below upwards:—

| | |
|---|---|
| 14. *Neocomian* . . . . . | Septariate nodules, dug for cement at Speeton. |
| 13. *Kimmeridge Clay* . . . | Ironshot nodules near the base of Kimmeridge Clay, near Helmsley. |
| 12. *Calcareous Grit* . . . | In Whitestone Cliff, base of the rock. |
| 11. *Kelloway Rock* . . . | At the top and in the middle. Hackness, Newtondale. |
| 10. *Cornbrash* . . . . . | Of poor quality, in Newtondale. |
| 9. *Upper Estuarine* . . . | The granular bands, or rich scattered lumps. |

| | |
|---|---|
| 8. *Grey Limestone* . . . | Bands of nodules of good quality over this rock. White Nab. |
| 7. *Middle Estuarine*. . . | Irregular nodular deposits. |
| 6. *Millepore-Oolite* . . . | A few nodules, some irregular patches above and at top of the Millepore-Oolite. |
| 5. *Lower Estuarine* . . . | Irregular nodular deposits. |
| 4. *Inferior Oolite*. . . . | "Dogger," extremely variable, locally very rich. Rosedale, Thirsk, &c. |
| 3. *Upper Lias*. . . . . | Nodules more or less calcareo-ferruginous in the alum-shale (below the cement-stone-beds). Saltwick.<br>Nodules more or less calcareo-ferruginous in strata in and below the jet-bed. Sandsend, Kettleness. |
| 2. *Middle Lias* . . . . | The great Cleveland band, containing usually several beds. Staithes, Eston, &c.<br>Irregular interspersed balls, beds, and patches in the marlstone. Staithes. |
| 1. *Lower Lias* . . . . | Many bands and balls scattered through the Lower Lias. Rockcliff, Huntcliff. |

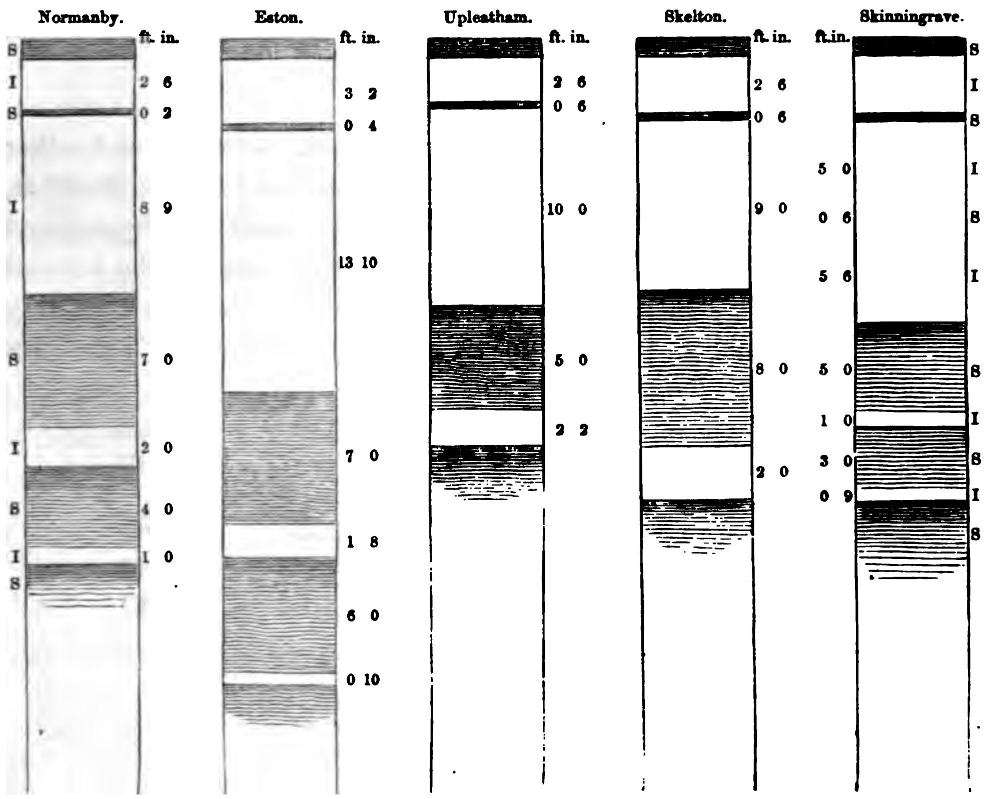
Several of these layers may as well be regarded as ferruginous cement-stones; others are largely calcareous, and may be used for water-setting lime; but all are ferruginous to some extent, and deserve notice in considering the distribution of the carbonate and sesquioxide of iron in segregated masses of various forms through so large a range of strata. Pyrites accompanies many of the balls in the Lias shales.

The Cleveland ironstone, according to my early classification of the strata on the Yorkshire coast, which has not been disturbed, lies in the upper part of the Middle Lias, the best and most productive beds being about 50 feet above the marlstone, and 200 or more feet below the Dogger, which, as already shown, is often another band of ironstone.

A line drawn not directly to the westward from Robin Hood's Bay, but a little to the south of west, will mark with sufficient accuracy the southern limit of productiveness of the Cleveland band,—not its whole extent; for, in fact, traces at least are found much further to the south, near Thirsk. Within the area between this line and the sea-coast, about

200 square miles of country contain the ironstone, mostly in a favourable condition for working, both as to thickness and quality; but it is nowhere so accessible or so productive as on the sea-coast west of Whitby, and on the fronts of the Cleveland hills; and there the mining-operations are now established with success.

*Sections of the Ironstone Bands on the Northern Line of Workings.*




I, Ironstone. S, Shale.

The point where the ironstone appears consolidated into the thickest mass is at Eston Nab; and from this point, both eastward and southward, there is a tendency to subdivision of beds and reduction of thickness. This may be understood by means of a few comparative sections, arranged right and left of Eston Nab as a central standard.

In respect of quality and richness in iron, there is not much difference

in the ironstone obtained from the different localities. Three tons of the ore are usually required for a ton of pig iron. Most of the ores contain more phosphorus than is desirable—a circumstance also noticed in the liassic and oolitic ores of Lincolnshire, Northamptonshire, and Oxfordshire. None of this ore, so far as my experiments go, obeys the magnet till it is calcined. It is partly oolitic in grain, partly compact, partly shelly, altogether greyish blue under ground and where unbathed by air and water-currents; but where these have had effect it is embrowned, at least in the exterior parts of the blocks.

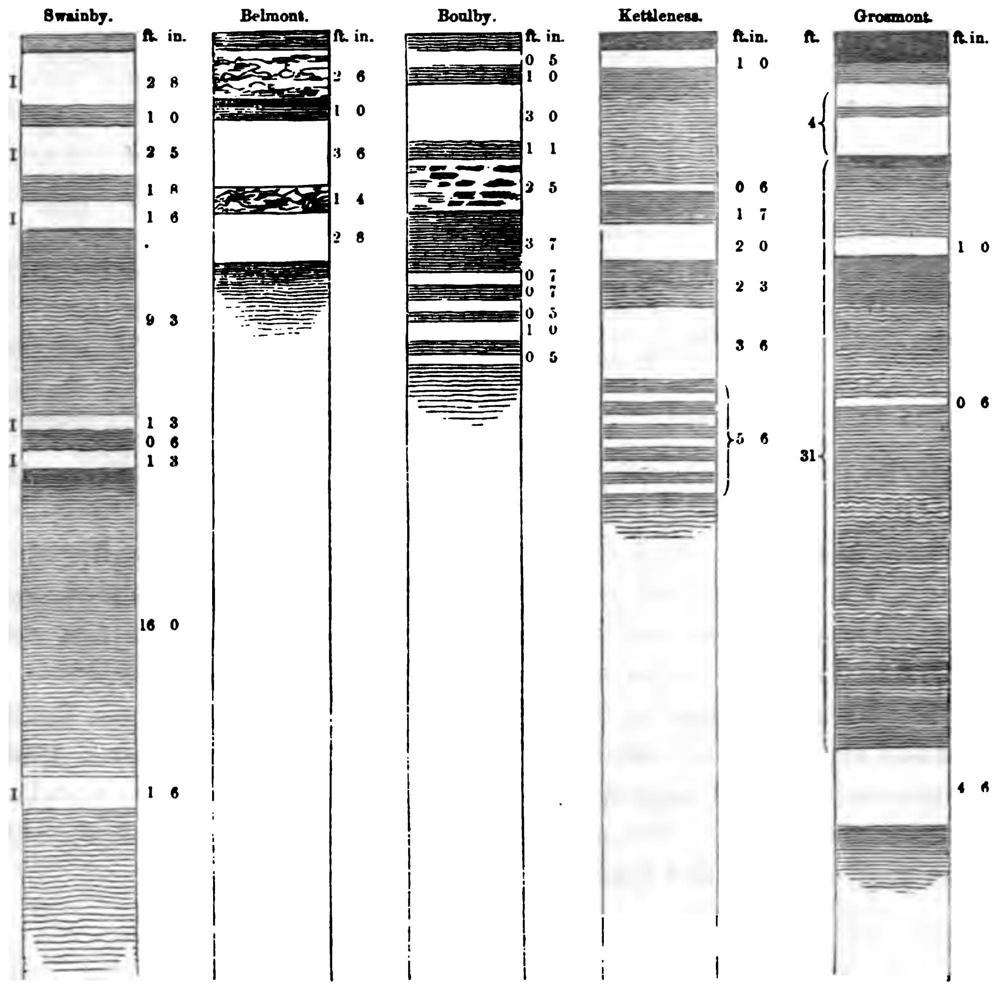
Though very solid in Eston Nab, Upleatham, Belmont, and other localities, it becomes more or less nodular as we proceed toward Staithes, and at the same time more shelly, especially belemnitic. Crystallized carbonate of lime and stalagmitic sheets appear in some of the vertical joints; and pyritous bands are seen here and there in the accompanying shales. The specific gravity is from 2·8 to 2·9. Mr. Crowther's analyses give the following amongst many results* :—

| | Per cent. |
|---|---|
| Normanby, maximum per cent. 32·96 | 30·62 |
| Eston Nab, seven specimens from the top to the bottom, maximum per cent. 35·10, minimum† 21·1, mean | 31·27 |
| Upleatham | 31·85 |
| In Eskdale, near Whitby | 29·21 |

* Edinburgh New Philosophical Journal, 1857.

† Taken from a shelly part of the bed.

*Sections of the Ironstone Bands on the Southern Line of Workings.*




Phosphoric acid and sulphur are detected in all these ironstones, each being on the average above one per cent.

As an example of the results of chemical examination in different parts of the same bed, the following complete analysis of the thick bed at Kildale, executed by Mr. Pattison at the Clarence Works on the Tees, has been communicated by Mr. Bell :—

| | Top foot. | 2nd foot from top. | 3rd foot from top. | 4th foot from top. | 5th foot from top. | 6th foot from top. | Bottom, 7th foot from top. |
|---|---|---|---|---|---|---|---|
| Protoxide of iron ........ | 40·50 | 31·95 | 33·56 | 28·28 | 15·43 | 14·91 | 32·01 |
| Peroxide of iron .......... | 2·80 | 9·50 | 4·14 | 8·71 | 1·30 | 1·80 | 2·43 |
| Protoxide of manganese.... | 0·37 | 0·60 | 0·55 | 0·54 | 0·37 | 0·37 | 0·35 |
| Alumina ................ | 5·43 | 10·34 | 9·03 | 11·57 | 5·38 | 6·25 | 9·23 |
| Lime .................. | 4·34 | 3·17 | 4·48 | 4·90 | 29·31 | 28·00 | 3·80 |
| Magnesia .............. | 3·21 | 3·22 | 3·21 | 2·97 | 2·25 | 2·60 | 4·31 |
| Silica .................. | 9·27 | 15·47 | 16·00 | 18·60 | 10·17 | 11·13 | 15·27 |
| Carbonic acid ............ | 28·60 | 18·80 | 22·80 | 17·00 | 29·60 | 29·80 | 26·80 |
| Phosphoric acid .......... | 0·98 | 1·09 | 0·94 | 1·02 | 2·35 | 1·92 | 1·30 |
| Water .................. | 3·06 | 5·85 | 4·71 | 6·29 | 2·46 | 2·43 | 3·20 |
| Sulphur* ................ | .... | .... | .... | .... | .... | .... | 1·12 |
| | 98·56 | 99·99 | 99·42 | 99·88 | 98·62 | 99·21 | 99·82 |
| Total metallic iron ........ | 33·45 | 31·50 | 29·00 | 28·10 | 12·90 | 12·85 | 26·60 |

The small quantities of potash and carbonaceous matter were not estimated.

The samples of the 2nd, 3rd, and 4th foot were slightly "weathered" (that is, had been exposed to the action of the air and moisture for some time), as may be seen from the large proportions of peroxide of iron and water and the small proportion of carbonic acid they contain.

The carbonate of lime in the 5th- and 6th-foot samples exists as small confused crystals, which are interspersed with a number of pebble-shaped nodules containing a large quantity of phosphoric acid. These nodules varied in size from the size of a pea to that of a chestnut. A number of them were collected and analyzed. They contained:—

| | | |
|---|---|---|
| Alumina . . . . . . . . . . . | 27·97 | per cent. |
| Lime . . . . . . . . . . . . | 12·92 | ,, |
| Magnesia . . . . . . . . . . . | 0·72 | ,, |
| Peroxide of iron . . . . . . . . | 0·70 | ,, |
| Protoxide of iron . . . . . . . . | 4·08 | ,, |
| Phosphoric acid . . . . . . . . | 28·27 | ,, |
| Sulphur . . . . . . . . . . . . | 0·52 | ,, |
| Carbonic acid . . . . . . . . | 4·00 | ,, |
| Soda . . . . . . . . . . . . . | 0·40 | ,, |
| Carbonaceous matter . . . . . . | 1·27 | ,, |
| Water . . . . . . . . . . . . | 2·84 | ,, |
| Insoluble in hydrochloric acid . . . | 15·60 | ,, |
| | 99·29 | ,, |

* Sulphur not estimated; but there is only a very small quantity.

When these nodules exist in conjunction with stone containing as much carbonate of lime as the 5th- and 6th-foot samples given on the other side, they are easily separated by calcining the stone and afterwards slaking the lime. The lime "falls;" and the nodules can be obtained by passing the powder through a sieve. The stone containing the nodules, however, has not always this composition, but contains too little lime to "fall" after burning and slaking. A larger sample (about 1 cwt.) of the stone sent here to calcine would not "fall." It contained 25·8 per cent. of metallic iron. It had not the crystalline fracture of the first sample. The appearance of the stone is a sufficient indication whether it contains a sufficient amount of lime to "fall" after calcination.

From the same laboratory, by the kindness of Mr. Bell, I append a copy of Mr. Pattinson's analysis of the sulphur-band which is found at the top of the thick bed at Normanby and other places.

The sample was taken in the state in which it leaves the mine:—

| | per cent. |
|---|---|
| Bisulphuret of iron | 53·19=28·37 sulphur. |
| Protoxide of iron | 9·97 |
| Alumina | 8·74 |
| Lime | 0·49 |
| Magnesia | 1·07 |
| Phosphoric acid | trace |
| Water | 13·20 |
| Insoluble in hydrochloric acid | 10·94 |
| | 97·60 |

In the Cleveland district, on the sea-coast, in Eskdale and Rosedale and along the front of the Hambleton hills, occurs the sixth band of ironstone, just above the Lias. This is the "Dogger" of the alum-works, the lowest part of the Inferior Oolite. Wherever it occurs in Yorkshire it is considerably ferruginous; and there is a belt of country, stretching from the sea-coast about Runswick, across Eskdale, Glaizedale, Rosedale, Farndale and Bilsdale to the hills above Thirsk, along which it has been opened and worked with more or less success. Near Rosedale Abbey part of the

ore is magnetic, and yields at a maximum 49·17 per cent. iron, with an average of about 40 per cent. From this, the richest point known, the proportion of iron diminishes; but for a mile or two it still contains a larger quantity of iron than the average of the Cleveland ore. The tract is nowhere so broad as in Rosedale; nowhere else is the bed so thick, nowhere else of so rich a quality. Rosedale Cliff near Staithes, the coast near Upgang, Beckfoot in Eskdale, Boltby near Thirsk, and Kirkham come next in point of importance; and at these situations the rock has been fairly tried.

It cannot, however, in the presence of the great Cleveland band be found advantageous to continue the excavations, except under very favourable local conditions, such as proximity to existing furnaces, or to mix with the ore of the "lower band."

BUILDING-STONE has been obtained from every calcareous and arenaceous rock in this district. The use of the chalk and marlstone is very limited; but the other strata have been extensively employed in old churches and mansions, and even transported to considerable distances. The most valuable appear to be:—the calcareous grit employed in the edifices of Castle Howard and Duncombe Park; the Kelloway sandstone, of which the hall and old church at Hackness and the Museums at York and Scarborough are constructed; and the freestone of the Lower Sandstone series, which has been shipped in great quantity from Whitby, being much esteemed for piers and bridges and other works requiring large blocks of stone. Guisborough priory and other ancient buildings in the northern part of the district prove the durability of this stone; and Whitby Abbey, though desolate and neglected and exposed on a bare sea-cliff, has not lost all its beautiful tracery. The calcareous grit and the Kelloway rock at Hackness seem equally durable, and are, in general, of a finer grain and more uniform colour.

FLAGSTONE, of excellent quality, is dug on the estate of Hackness, and, being conveniently situated near the sea and a railway, may probably be sent on favourable terms to the London market. It also occurs

in good condition in the cliffs of Cloughton and Haiburn, and in Newtondale.

LIME is obtained from the Chalk, Coralline Oolite, and Grey Limestone, or Cave oolite; and some less successful trials have been made upon the calcareous Dogger. The hard chalk of Flamborough is transported for this purpose to Whitby and other places on the coast; and a considerable trade in lime is carried on at Hessle. The coralline oolite is burnt extensively about Seamer, Ayton, Pickering, and Malton, and the thinner oolite below with more or less advantage at Hawsker, Maybecks, Commondale, Scugdale, Coxwold, Newborough Park, Brandsby, Westow, Sancton, Ellerker, &c. The lime from the oolites is less pure than that from the chalk; but all kinds are used in agriculture, as well as for building.

BRICKS are very generally used in Holderness and the Vale of York, where the diluvial clay is an abundant and suitable material, and in Cleveland, where the Lias clays furnish an additional supply. In the moorland valleys the shales might be employed for the same purposes, if the prevalence of sandstone did not render it unnecessary.

The nodules and layers of FLINT which occur in the chalk of the Wolds might be of value in the neighbourhood of potteries, but at present provide excellent materials for the roads. The basaltic dyke, the Bath oolites, slaty stone of Brandsby, and coral-bed of the Pickering oolite furnish very good stone for this use; and, in their absence, Holderness and the Vale of York yield plenty of waterworn gravel.

Excepting limestone, the agriculturist employs none of the mineral productions of the eastern part of Yorkshire as MANURE. Possibly some varieties of the red and white marls near the mouth of the Tees might be available in this respect, as they are in the midland counties. In Holderness, the shell marl so generally found beneath the lacustrine deposits of peat might, perhaps, be found useful if spread on the pastures; but it could hardly fail to produce excellent effects if employed upon the peat

itself, in the mode adopted in the northern part of Lancashire. If this suggestion should be found correct, considerable benefit would result from the practice; for many such peaty hollows exist in the interior of Holderness, which can neither be obliterated by a covering of warp nor corrected by ordinary industry.

COAL occurs extensively in the north-eastern part of Yorkshire, in the sandstone series between the grey limestone and the Dogger, but always in thin seams, and generally of inferior quality. The immense advantages which would arise to this district from the working of thick seams of good coal, sufficiently account for the many unsuccessful attempts to discover them. The opinions of *working colliers* on this point have too often been preferred to the legitimate deductions of science; and even yet persons will perhaps be found willing to credit the delusive tale of finding good coal by *going deeper*. But the warning must be given, though it be disregarded; and from all the natural exhibitions on the coast, as well as from the result of every experiment inland, I am compelled to state that any hope of discovering seams of coal more than 18 inches or 2 feet in thickness, in any part of the strata *above* the Upper Lias or alum-shale, is entirely unsupported by reason and experience. That the Coal-measures of Durham and Western Yorkshire exist (covered by magnesian limestone and red sandstone) *beneath* the Lias, is probable; but the practicability of reaching them by pits, even in Cleveland or near York, is very questionable, and the cost of the experiment may be ruinous (see p. 5).

Of several thin and variable seams of coal which appear among the sandstone rocks above the Lias, only the lower one immediately above the Dogger, and the upper one beneath the grey limestone, have been found worth the expense of working. The upper seam is the most regular, and has been worked at Cloughton Wyke, Maybecks, Goadland, Glaizedale, Danby, Shunnor Hoe, Blakehoe, Rudland, Coxwold, Newborough Park, Colton, &c. That this and the lower seam may be opened in new places is highly probable; and such attempts may be productive of some local advantage; but they should be guided by *geological induction*, and not abandoned to *ignorance and empiricism*.

The manufacture of ALUM from the Upper Lias shale has furnished extensive employment and considerable emolument; but there appears little encouragement to establish works in new situations. The principal material in the process does not retain its essential characters much further south than the present establishments; and the difficulty of transporting materials to a distance will probably confine the trade to the vicinity of the Peak, Lyth, Kettleness, Boulby, Rockcliff, and Guisborough.

JET, now one of the most valuable products of the Yorkshire coast, has probably been known and worked into ornaments ever since the Roman road reached the Bay at Sandsend. It is simply coniferous wood, and in thin sections shows clearly the characteristic structure; frequently resin masses, of oval figure, enveloping larger tissue than occurs elsewhere appear under the microscope. Impressions of Ammonites and other fossils appear on surfaces of jet, and prove that it had passed through a condition of softness.

The best jet, a hard compressed mass, occurs near the base of the Upper Lias, and less plentifully in other parts of that rock. "Soft jet," of less firm texture, is obtained from the sandstones and shales of the Oolitic series.

PETROLEUM is found chiefly in hard shales and nodules above the Jet-beds, bathing the fissures of the rock and entering the cavities of Ammonites, from which circumstance it has sometimes been supposed to be of animal origin. A sort of distillation from the jet-making plants appears more likely.

PYRITES is very common in all the clays of East Yorkshire, notably so in the Lias, where it forms often the exterior sheath round coniferous wood, and gathers round Ammonites, Belemnites, and Pentacrinites. Some shells, as those of *Ammonites Mulgravius* and *Inoceramus dubius*, have been apparently converted to this substance (which abounds in a bed in the upper part of the Eston Ironstone series), so as to yield 28·37 per cent.

of sulphur. The presence of so much sulphur in the Lias and other clays is not very easily explained. The opinion is acquiring favour which attributes to sublimation, from deep sources, of chlorides, sulphides, &c. a considerable share in the impregnation of metallic veins; and M. Daubrée, in a late notice*, speaks in this relation of the cupriferous slaty beds of Thuringia. There seems, however, in the remarkable aggregation of pyrites about the alveolar chamber of a Belemnite which is common in the Upper Lias, an indication of the derivation of the sulphur from the bodies of these invertebrate animals.

GYPSUM occurs in irregular beds and ramifications in the Upper Triassic marls on the Tees, near Coatham, and has been penetrated by borings. Crystals of this substance (selenite), of small size, formed apparently in small cracks and fissures, occur in some parts of the drift near the Spa, Scarborough.

BARYTINE.—Professor Daubrée quotes this mineral as occurring on the surfaces of fossils at Whitby. It is found among other crystallizations, as quartz, calcite, carbonate of iron, galena, by the side of the Cleveland Dyke.

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## ROCK-SALT.

The discovery of rock-salt in large quantity at Middlesborough by Messrs. Bolckow and Vaughan, leads to some interesting questions, both geological and economical. In what part of the series of strata does it occur? what inferences in relation to the discovery of coal at a greater depth may be founded on this occurrence? what is the commercial value of the discovery?

According to the report of Mr. Armstrong (1869), the boring presented the following strata; the salt is supposed not to have been bored through:—

* Read to the Geol. Soc. of France, August 7, 1871.

| | | | feet. |
|---|---|---|---|
| Mud, loamy sand, and clay | | | 58 |
| Rock mixed with clay | | | 12 |
| Rock mixed with gypsum, and including two beds of gypsum of 2 feet and 6 feet respectively | | | 69 |
| White and red sandstone and gypsum veins | | | 1067 |
| Salt | very dark | 4 ft. 1 in. | 100 |
| | rather dark | 39 ft. 11 in. | |
| | rather light | 9 ft. 0 in. | |
| | very light | 47 ft. 0 in. | |
| Total | | | 1306 |

Rock-salt, viewed in a general manner, is not confined to the Triassic strata; it occurs in subcretaceous beds in Spain, and in tertiary beds in Poland. In Germany the salt rocks and considerable salt springs are found in the Lower, Middle, and Upper Trias. In England they have been usually referred to the Upper Trias, in which they occur in limited tracts, of one or a few miles in the greatest dimension. The greatest thickness which has been attributed to the Upper Trias is in Cheshire, where Mr. Ormerod estimated it at 700 feet above the salt, and 400 feet below it. He also assigned to the Red Sandstones below 600 feet*.

In my examination of these strata in the vale of the Severn, the whole of the Upper Trias was found to be 750 feet, and the Red Sandstones below 400 feet. The Droitwich salt springs in this district are referred to the Upper Trias.

The depth from the surface to the Middlesborough salt is much greater than the sinkings in Cheshire or Worcestershire, but is exceeded by the deep boring at Kissingen, which reached 2000 feet. It does not begin at the top of the New Red marls, but in some part of the Gypseous series, which is seen in cliffs lower down the Tees. Other borings, at Kirk-Leavington to a depth of 120 fathoms, and at Middleton-one-Row to above 100 fathoms, contribute data toward determining in what part of the Triassic series the Teesdale salt is found. Of these, the trial at Kirk-Leavington near Yarm is the most instructive, if the designations

* Memoirs of the Geological Survey, vol. ii.

of the rocks penetrated can be depended on. The boring began 74 feet above high-water line, and probably at a depth in the Trias of 200 or 300 feet:—

| WORKMEN'S REPORT. | ft. | in. | ft. | in. | CONJECTURAL CLASSIFICATION. |
|---|---|---|---|---|---|
| Reddish clay | | | 27 | 0 | Lower part of the Keuper, or Upper Trias. |
| Fine and coarse sand | | | 21 | 0 | |
| Reddish clay | | | 51 | 0 | |
| | | | | | (No Middle Trias). |
| Yellow and white sandstone and sand and gravel | | | 10 | 2 | Upper part of the Lower Trias, or "Water-stones." |
| Light bluish sandstone | | | 119 | 10 | |
| Hard white sandstone and fire-clay | | | 4 | 10 | |
| Red-sandstone beds | | | 204 | 3 | The Lower Trias, or Bunter-Sandstone Series. |
| Red sandstone with thin alternations of red clay, red fake and blue | | | 75 | 3 | |
| Magnesian limestone | 6 | 9 | 42 | 8 | |
| Red fake and clay | 11 | 8 | | | |
| Red fireclay | 9 | 5 | | | |
| Magnesian limestone | 6 | 0 | | | |
| Red fake and clay | 2 | 3 | | | |
| Magnesian limestone | 1 | 6 | | | |
| Red fake and clay | 5 | 1 | | | |
| Red sandstone, hard | | | 19 | 2 | |
| Red sandstone and fake | 6 | 4½ | 47 | 10 | |
| Red shale and sandstone with threads of grey metalstone | 16 | 2½ | | | |
| Grey pyritic sandstone | 1 | 0 | | | |
| Red shale and bands of hard red sandstone | 24 | 3 | | | |
| GYPSUM (called chalk or pipeclay by the workmen) | | | 0 | 9 | Gypseous clays, &c. above the Permian limestones. |
| | | | 623 | 9 | |

According to this conjectural classification, the Bunter sandstone of Croft, Middleton-one-Row, and Yarm is found above gypseous beds at Kirk-Leavington; and we may suppose the sandstones "white and red" of the Middlesborough boring to be of the same type. This would bring

the salt of Middlesborough to a position in the lower, if not the lowest, part of the Trias; and Permian beds of some kind might be looked for at no great depth below.

If we take another view, and range the salt of Middlesborough on the parallel of the Cheshire deposit, there is the great difficulty of thickness; for if we add to the actual depth of 1306 feet 200 or 300 feet more for the Upper Trias not penetrated, we obtain a result quite unexampled, and, taking into account the general inclinations of the mesozoic strata, hardly admissible. Regarded generally, the dips from the Cleveland Hills (including rolls and faults), eastward to the coast, southward to Rosedale and Thirsk, do not exceed 60 or 70 feet in a mile, a common estimate for these strata in England. According to this view, the Lower Triassic beds could not be expected to dip from Croft or Sedgfield so that their upper surface should sink 1400 or 1500 or more feet in the distance of 10 or 15 miles. If it be so, or a great fault be assumed throwing down to the south, local circumstances must be imagined to have produced an uncommon thickness of the Upper Triassic strata; and for this there is no independent probability. On the whole the former appears at present the preferable opinion.

Both by reason of the great mass of salt and its comparative purity, the discovery must be regarded as of high commercial value. Upon analysis, according to Mr. Marley, the salt yielded:—

| | |
|---|---|
| Chloride of sodium | 96·63 |
| Sulphate of lime | 3·09 |
| Sulphate of magnesia | ·08 |
| Sulphate of soda | ·10 |
| Silica | ·06 |
| Iron | trace |
| Water | ·04 |

# CHAPTER XIV.

## THE BASALTIC DYKE.

ONE of the most remarkable features on a geological map of England is the line of the great trap dyke, from beyond Cockfield Fell in Durham to the Sneaton moors in Yorkshire, a distance of 60 miles. That this subterranean wall of basalt is really connected through the whole of this length, few will be inclined to dispute who have studied the character of the rock, and observed its bearings at Cockfield Fell, Bolam, Langbargh, and Silhoue Cross; but it is not traceable between all these points on the surface of the ground; very probably it does not everywhere reach to the surface, because of some discontinuity or impediment in the fissure. It is a common opinion that this dyke is united, toward the west, with the "great whin sill," or basaltic formation of Upper Teesdale, from the eastern end of which another long dyke appears to arise; but the actual junction is not traced. The earliest date to be assigned to the dyke is the middle part of the Bath Oolitē period. It may have been of much later date. On the east it does not reach the sea-side, but terminates obscurely after crossing near its source the easternmost branch of Littlĕbeck. The direction to which the eastern part points might connect it with the small dislocation of Haiburn Wyke, the great fault at the Peak being quite out of the probable course. Its general direction is E.S.E. and W.N.W.; but in several places considerable deviations in this respect are observable. The breadth is commonly about 60 feet, as at Cockfield Fell, Langbargh quarry, and Egton; but it diminishes to less than 30 feet at the eastern extremity. At Bolam in Durham, it expands into a large pyriform mass, having the appearance of an interposed bed, resting on black shale. The sides of the dyke are seldom perpendicular, but generally slope downwards toward the north. At Langbargh quarry this slope is about 1 in 8. The strata through which the dyke passes are

generally dislocated, so that a given layer is found considerably higher on the south side than on the north.

As might be expected, this hard rock has been less wasted by watery currents and the changes of the atmosphere than the softer strata which bound it, and therefore in some places it appears above them in a long crest or ridge. On Clifton Rigg its blocks, lying bare on the surface, have been compared to prostrate pilasters half buried in ruins; near Egton Bridge it stands up in a lofty wall, over the waters of the Esk; and beyond Silhoue Cross it ranges along the moors like an ancient military road; but in a large portion of its course, especially in the wide vale of the Tees, it is concealed by diluvial accumulations.

The composition of the basalt presents few peculiarities. Olivine, calcareous spar, mesotype, and quartz are the principal extraneous minerals. Hollow geodes occur in it, of which the walls are amethystine quartz, presenting crystalline facets to the cavity, which contains a crystal of carbonate of lime. The joints, which are often lined by a sooty substance, are in most quarries irregular, and lie in all directions; but sometimes a tendency may be noticed to that horizontal prismatic structure which prevails in narrower dykes of the same substance in the Island of Arran. At Bolam, in Durham, where the mass extends itself more horizontally, the pseudo-prisms approach to a vertical position. Thin, flexuous, irregular, nearly horizontal layers of basalt appear in Langbargh quarry, and decomposing balls, with ochry outsides, are common.

The following strata are divided by this remarkable dyke, viz.:—Mountain-limestone near Middleton; sandstone, shale, and coal in Durham; Magnesian Limestone, New Red Sandstone, and Red Marl in Durham and the north of Yorkshire; Lias shale &c., and the lower sandstones of the Oolitic series, in the north-eastern moorlands. These strata, where they come in contact with the basalt, are more or less altered in appearance and composition; and the change seems generally due to the action of heat. At Cockfield Fell the coal near the dyke is converted to a black substance like concreted soot, at a small distance changed to a cinder

without bitumen or sulphur, and beyond gradually regains its usual properties. "In the stratum above the cinder a great deal of sulphur is sometimes found, in angular forms, of a bright yellow colour, and very beautiful" *. "At Berwick-on-the-Tees the white sandstone is usually a good workable freestone—but where the dyke passes through it, is so much indurated as to be unfit for masonry, and is only employed for embankments and similar purposes. Along the whole range by Langbargh, Kirkdale, and Eskdale the action of heat upon the contiguous shale is plainly discernible: part of it has been quite bleached, and greatly indurated; in other parts it has the aspect of scoria, and the iron appears as a loose yellow ochre" †. At Egton Bridge the blue Lias shale is changed by the dyke to a white or pale greenish yellow, and made to resemble jasper in hardness. A white indurated earth in some places separates the dyke from the neighbouring strata; and occasionally the external portions of the basalt are altered to a friable mass, the iron oxidated, and the felspar decomposed to porcelain clay. Among the minerals which owe their locality to the dyke, are galena, sulphate of baryta, carbonate of iron, and quartz, all crystallized in proximity to the erupted rock.

* Mr. D. Tuke, in a communication to the Yorkshire Philosophical Society. By "sulphur," used in a miner's sense, we must understand iron-pyrites.

† Rev. L. V. Harcourt, in a valuable communication on the geology of Cleveland.

# CHAPTER XV.

## ORGANIC REMAINS—PLANTS.

A LARGE part of the series of Mesozoic life, as known in the northern zones of the earth, is represented by the Fossils of the Yorkshire coast,—not the whole, since we have little or nothing to show for the Triassic ages, and the interval between Kimmeridge Clay and Chalk, though filled with interesting remains, exhibits chiefly one large series of argillaceous sediments. The land and freshwater life of the Oolitic period is abundantly represented by ferns, Zamiæ, and conifers, a few bivalve shells, and crustaceans. Marine life is fully, if not continuously, exhibited from near the base of the Lias to the upper zones of the Chalk.

Since the former issues of this work the search for fossils in the Yorkshire cliffs, which had been prosecuted with unrivalled success by Mr. Bean and Mr. Williamson, has been continued by many followers not unworthy of such admirable leaders. Not very many new forms of life have thus been discovered; but the means for specific discrimination, and for comparison with analogous fossils in the south of England, have been increased. Careful descriptions of several groups of Yorkshire fossils (from the Lias and Oolites) have been prepared by Sir C. Bunbury, Mr. Leckenby, Dr. Lycett, Professor Morris, Mr. Simpson, Professor Williamson, and Dr. Wright. Their labours refer to plants and invertebrata, while the cabinets of the Earl of Enniskillen and Sir Philip Egerton are rich repositories of the fishes from the Whitby Lias to the Speeton Clays. Some noble additions which have been made to the short catalogue of Reptiles may be well seen in the Yorkshire Museum.

Formerly the fine and well-arranged cabinets of Mr. Bean and Mr. Williamson and Dr. Murray were freely open for study; but of these collections only one remains on the coast (in the Scarborough Museum), the others must be looked for divided among distant localities. Mr. Leckenby, indeed, in a considerable degree remedied this unfortunate

dispersion by wisely and liberally amassing a splendid series of selected specimens, including many of those which belonged to Mr. Bean and Dr. Murray; and these have now found an honoured residence in the Geological Museum of Cambridge. The public museums of Scarborough and Whitby contain many admirable specimens; but additional space is required for convenient exhibition and study. In the museum at York two spacious rooms are devoted to collections of Yorkshire fossils; and these are numerous, and only require fresh supplies of specimens chosen for novelty, rarity, or excellent condition.

My own cabinets contain many things, the fruit of my own labour with hammer and chisel. Professor Williamson has communicated accurate drawings, and Mr. Peter Cullen has supplied me with specimens, of plants of the Oolitic series; and useful additions, especially among Ammonites, have been obtained from Mr. Marshall and other collectors at Whitby. Time has brought many changes of nomenclature since 1829 and 1836. On these points the experience of Mr. Etheridge, and the monographs of Davidson, De Zigno, Duncan, Lycett, and Wright have been consulted. After estimating the information obtained from these various sources, I find myself able to make additions to the former catalogue, especially among the plants, the Cephalopoda, and the reptiles; and I have the advantage of referring to the great work on Trigoniæ now in progress by Dr. Lycett, and to the catalogues of Fishes prepared by the Earl of Enniskillen and Sir Philip Egerton; Mr. Dawkins, Mr. Gwyn Jeffreys, and Mr. Leckenby have revised the lists of Cainozoic fossils; so that what follows is a record of ancient life in the Yorkshire basin and neighbouring land, as complete as the state of my knowledge admits, under the heads of Plants, Invertebrata, and Vertebrata.

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*Abbreviations sometimes used in the following references to Fossil Plants.*

Br. V. F. *for* Brongniart, Végétaux Fossiles. L. & H. *for* Lindley and Hutton, Fossil Flora. Göpp. *for* Göppert, Systema Filicum fossilium. Sternb. *for* Sternberg, Flora der Vorwelt. Zign. *for* De Zigno, Flora Fossilis formationis Ooliticæ. Bunb. *for* Bunbury, in Geol. Journal, vol. vii. Leck. *for* Leckenby, in Geol. Journal, vol. xx. Pls. I., II., &c., fig. 1, 2, &c. refer to Plates and figures in this volume; Lign. 1, 2, &c. to the figures in the text.

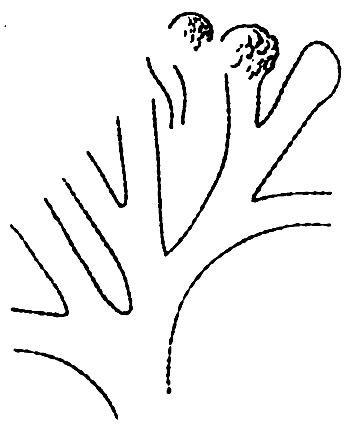
With few exceptions the Remains of Plants are confined to the sandstones and shales of the Oolitic and Liassic series, and are only plentiful and varied in those divisions of the former which intervene between the Cornbrash and the Dogger. The three groups of sandstone, ironstone, and shale which answer to this description are marked *u.* (Upper), *m.* (Middle), *l.* (Lower) in the sections of the coast (Pls. XV.–XXIII.).

The figures and descriptions are mostly from my own specimens, and are offered as a local contribution toward the general history of British Fossil Plants, which is now in the hands of Mr. Carruthers.

## ALGÆ.

Remains of marine plants are, as might be expected, rare in the marshy or lacustrine sediments of the Oolitic series in Yorkshire. They are of considerable interest, as showing the proximity of the sea-shore; for they belong to littoral forms.

Lign. 1.



*Fucoides arcuatus*, L. & H. tab. 185. [Lign. 1.]

Thallus expanded into curved bifid branches. There appear to be tuberculate enlarged terminations and traces of a thickened mesial band. The substance is represented by a brown stain.

From middle shale, Gristhorpe: in my Collection, not well preserved.

Lign. 2.

*Fucoides diffusus*, Phillips, n. s. [Lign. 2.]

Thallus reticulato-divaricate, with narrow branches; no trace of midrib. In figure it resembles *F. laceratus* of our coasts.

From Gristhorpe: in my Collection, not well preserved.

Lign. 3.

*Fucoides erectus*, Leckenby. [Lign. 3.]

Leckenby, whose figure (G. J. vol. xx. pl. xxi. f. 3) is here copied, notices what seem to be double lines of fructification along the middle of the branches. The terminations on the left side are all rounded and a little enlarged. The name was taken from Bean, MS.

From Gristhorpe and Cloughton Wyke: in the Leckenby Collection.

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## EQUISETACEÆ.

These are common in the middle and lower shales and sandstones, even to constituting great part of thin coal-beds; in some places erect in sandstone, in others rooted in shale.

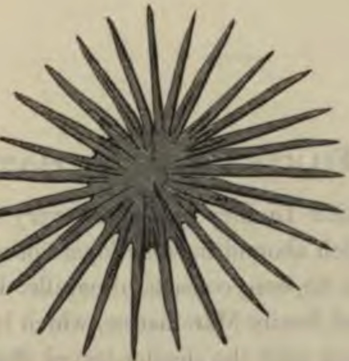
Lign. 4.


*a.* Portion of stem with dentiform processes and the bases of branches. *b.* Dentiform processes, which are finely striated above, as *d*, and rough below. *c.* A portion of the rough surface of the stem.

*Equisetites columnaris*, Br. V. F. tab. 13. [Lign. 4, 5.]

From middle shale, Gristhorpe, Cloughton; from lower shale and sandstone, Haiburn Wyke, Stainton dale, High Whitby.

Lign. 5.



Specimen showing dentiform sheath connected with a complete phragma. These objects are found separate from the stem; the phragma is rarely so well preserved.

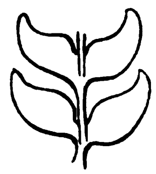
*Equisetites lateralis*, Ph. [Pl. X. fig. 3.]

From middle shale, Gristhorpe, Cloughton Wyke; lower shale, Haiburn Wyke. In my Collection are several specimens.

## LYCOPODIACEÆ.

Of the plants which, on a first view, were referred to this humble tribe, the greater part have since been classed with Coniferæ (*Walchia*, *Cryptomerites*).

Lign. 6.



*Lycopodites falcatus*, L. & H. tab. 61. [Lign. 6.]

Frond slender, expanded, much divided; stem slender, dichotomous, everywhere set with bifarious leaves, which are oval, arched, and turned forward, and contracted to the apex. Marks of stipulæ.

From Cloughton Wyke, middle shale.

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## FILICES AND ALLIED PLANTS.

*Solenites.*—Under this title Lindley placed the very slender, simple, or branched leaves, without midrib, which abound in some layers of middle and lower shale. The leaf-structure, as far as can be seen, consists of parallel lengthened cells. They have been referred to the natural family Marsiliaceæ, which includes *Isoetes* and *Pilularia*. They appear to have alliance with the slender-leaved *Baiera gracilis*, which conducts to the broad-leaved *Cyclopteris digitata*.

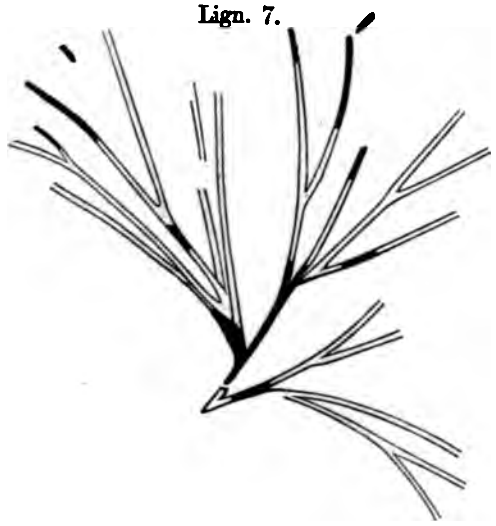
*Solenites Murrayanus*, L. & H. tab. 121. (*Isoetites*, Zign. *Flabellaria viminea*, Ph. 1829.) [Pl. X. fig. 12.]

Composed of long (undivided?), very narrow flat leaves, which spring in a tuft from a sheath or enlarged basis.

It is possible that these leaves are divided like the species of *Baiera*, by a furcation beginning nearer to the base; they may be compared to the leaf-tuft of a *Pinus*.

From middle shale, Gristhorpe and Cloughton Wyke: common.

Lign. 7.

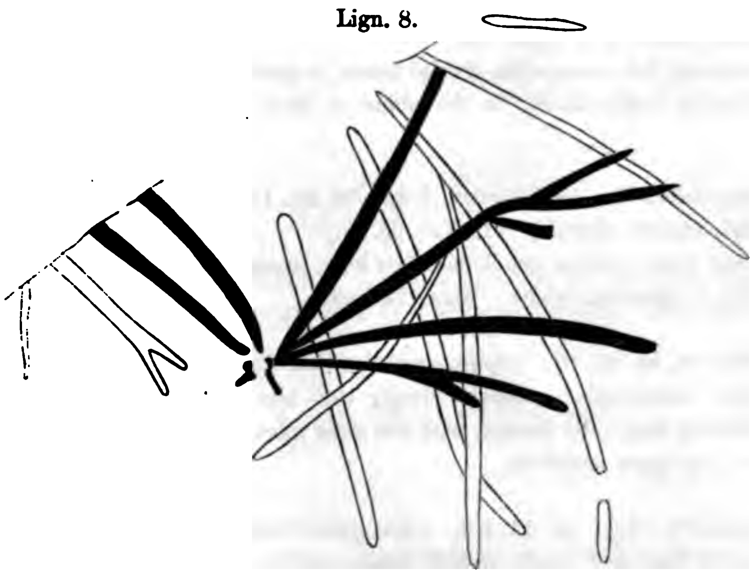


*Solenites furcatus*, L. & H. tab. 209. [Lign. 7.]

Frond composed of radiating, often furcate, long, very narrow flat leaves. It has much resemblance to *Fucus fastigiatus*, and other almost filiform dichotomous Algæ, as well as to such ferns as *Asplenium septentrionale*.

From Scalby, in upper shale and sandstone (my Collection); from Haiburn, in lower shale and sandstone (Williamson).

Lign. 8.



*Baiera gracilis*, Bunbury, G. J. vii. tab. 12. f. 3. (*Cyclopteris*, Zign.) [Lign. 8.]

Frond divided into eight long, narrow, obtuse leaves with longitudinal venation. The leaves

spring in pairs, from a common centre; some continue simple, others are once or twice forked. I possess a specimen, perhaps distinct, with four undivided narrow leaves.

From Scalby, in upper shale and sandstone (my Collection).

Lign. 9.


*a.* Natural size. *b.* Magnified.

*Baiera microphylla*, Ph. n. s. [Lign. 9.]

Composed of long, flat, acute, often divided leaves, in radiating tufts. Venation longitudinal.

From Gristhorpe, middle shale. In the cabinet of Prof. Williamson, whose drawing is here copied.

*Cyclopteris longifolia*, Ph. (*Sphenopteris longifolia*, Ph. 1829. *Cyclopteris digitata*, L. & H. *Cyclopteris Huttoni*, Sternb.) [Pl. VII. fig. 17.]

Frond furcate from a narrow petiole into four long, strongly striated leaves.

From Scalby, in upper sandstone. Bean's Collection.

*Cyclopteris digitata*, Br. tab. 61. (*Sphenopteris latifolia*, Ph. 1829.) [Pl. VII. fig. 18.]

Frond broad, semicircular, petiolate, deeply cleft into 2, 4, 8, or more striated lobes. Venation radiating, frequently furcate, with fine cross veinules.

From Scalby, in upper sandstone.

*Dichopteris lanceolata*, Zign. tab. 14. f. 2. (*Neuropteris lanceolata*, Ph. 1829.) [Pl. X. fig. 6.]

Frond set with long, oval, simple, smooth, subopposite leaves, with radiating furcate venation: no midrib.

From the lower sandstone and shale, Saltwick.

*Dichopteris lævigata*, Zign. tab. 14. f. 3. (*Neuropteris lævigata*, Ph. 1829. *Pachypteris ovata*, Br. tab. 45. f. 2.) [Pl. X. fig. 9.]

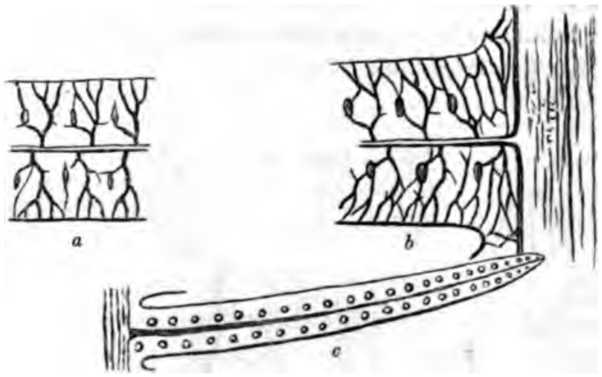
Frond bipinnate; pinnæ distant, elongate, set with oval, subopposite, smooth, sessile pinnulæ, with fine radiating furcate veins; no midrib.

From the lower sandstone and shale, Egton Moors, and Haiburn Wyke.

The two plants above mentioned have been generally supposed to be identical with two named by Brongniart *Pachypteris ovata* and *P. lanceolata*, which are represented as having a distinct midrib, and no veinules. The specimens, which were examined by Brongniart and myself in 1825, cannot now be found in the Yorkshire Museum. It appears to me that *Pachypteris ovata*, Br., is the same as *Dichopteris lævigata*, Zign. & Ph.; but the figure given by Brongniart for *Pachypteris lanceolata* is essentially different from mine.

*Phlebopteris.*—To this genus of Brongniart, with areolate venation on each side of a straight midrib, long narrow pinnulæ connate at the base, and sori arranged at the end of free veinules, as in recent Polypodiaceæ, the following five species, which are not very clearly distinguished, have been referred. The recent *Polypodium ramosum* may be taken for comparison.

Lign. 10.




*a. Phlebopteris polypodioides*, Br., middle of pinnule, magnified. *b.* Base of pinnule, magnified. In these drawings the places of the sori are marked by oval spaces. *c.* Pinnule, of natural size, with sori.

*Phlebopteris polypodioides*, Br. tab. 83. f. 1. [Lign. 10.]

Pinnulæ very long, entire at the edge; sori 20 or more in a row.

From the middle shale, Gristhorpe.

*Phlebopteris contigua*, L. & H. tab. 144.

Pinnulæ of moderate length, entire. A specimen in the Yorkshire Museum shows fructification.

From the middle shale, Gristhorpe.

*Phlebopteris crenifolia*, Ph. (*Pec. propinqua*, L. & H. tab. 119. *Polypodites*, Zign.) [Pl. VIII. fig. 11.]

Pinnulæ very long, crenated at the edge; sori as many as 30 in a row.

The crenulation is thought by Leckenby to be due to the development of the fructification; but De Zigno preserves the original nomenclature.

From the middle shale, Gristhorpe.

*Phlebopteris Woodwardii*, Leck. G. J. xx. pl. 8. fig. 6.

Areolæ pentagonal.

From middle shale, Gristhorpe.

*Phlebopteris Lindleyi*, Göpp. (*Phlebopteris polypodioides*, L. & H. tab. 60.)

From middle shale, Gristhorpe.

The venation is correctly drawn in the figure referred to, but only the principal lines appear.

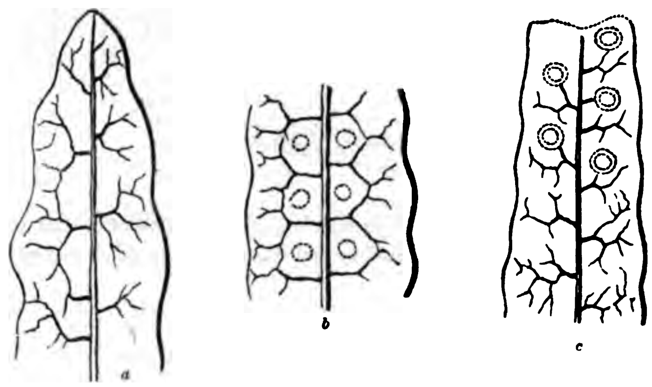
To the same genus Brongniart also referred the following remarkable and unlike forms:—

*Phlebopteris Phillipsii*, Br. (*Phyllites nervulosus*, Ph. *Dictyophyllum rugosum*, L. & H. tab. 104; Zign. tab. 23. f. 2. *Hemitelites heracleifolius*, Göpp.) [Pl. VIII. fig. 3; Lign. 11.]

Frond ramose, expanded into broad pinnæ with undulated edges and decurrent bases. Allied to the recent Australian fern *Polypodium Billardieri*.

From the middle shale, Gristhorpe.

Lign. 11.




*a. Phlebopteris Phillipsii*, end of a pinna. *b.* The same, toward the middle, showing the probable place of the sori. *c. Polypodium Billardieri*, showing the fructification.

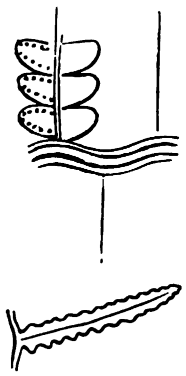
In the Cambridge Museum is a specimen showing a rachis sending off four connate broadly foliaceous branches. Other specimens in my Collection exhibit narrower and less irregular foliation; these are referred by De Zigno to a distinct species next to be mentioned.

*Phlebopteris Leckenbyi*, Zign. tab. 23. f. 1.

Frond ramose, expanded into narrow decurrent pinnæ, with undulate, crenated borders.

From the middle shale, Gristhorpe.

Lign. 12.



*Phlebopteris undans*, Br. (*Pecopteris undans*, L. & H. tab. 120. *Polypodites*, Zign.) [Lign. 12.]

Frond narrow, elongate; pinnæ closely set, very narrow, with flexuous midrib; pinnulæ (16) short, obtuse, tumid, closely set or connate, so as to resemble lobes. Venation not traced. Fructification in a line on each margin of the pinnulæ.

From middle shale, Gristhorpe.

*Glossopteris Phillipsii*, Br. tab. 61 bis. f. 5; tab. 63. f. 2. (*Pecopteris paucifolia*, Ph. 1829. *Sagenopteris*, Sternb. *Phyllopteris* et *Sagenopteris*, Zign.) [Pl. VIII. fig. 8.]

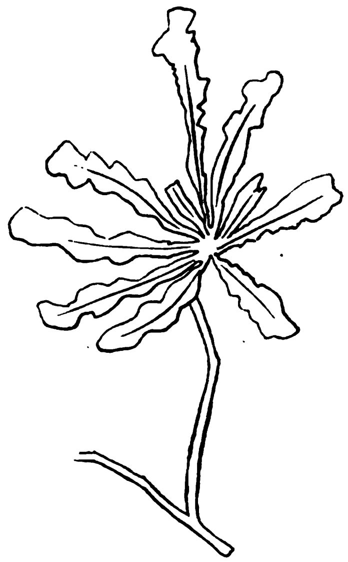
Frond four-leaved; leaves lanceolate, entire, springing together; veins numerous, dichotomous, anastomosing near the seeming midrib, which consists of several parallel veins. Substance thick; greatest length of a leaf 3½ inches.

From the middle shale, Gristhorpe.

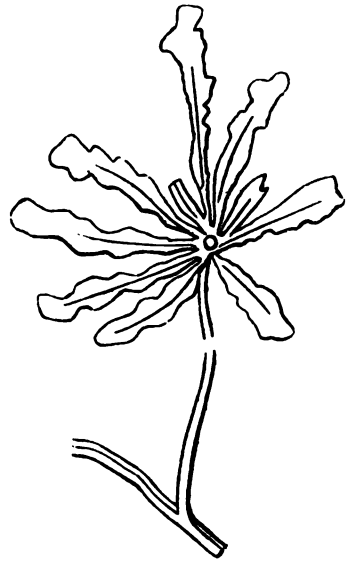
This species, easily recognizable in specimens, has been so variously represented in engravings and lithographs as to be the cause of much confusion. The drawings communicated by myself to M. Brongniart (V. F. tab. 63. f. 2), and the representation in my first edition (both lithographs), were intended to show the general aspect of natural size unaided by a lens. In my second edition the veins were represented with care (by engraving) from the same narrow leaves. Finally, an elaborate drawing by Miss Thornhill, showing areolate venation over the whole leaf, was copied in the 'Fossil Flora,' tab. 63. There is probably but one species, with some variation in the venation, and a considerable difference in the length of the leaves, among my specimens; none are without some anastomosis and areolation, and none with so much or so uniform a reticulation as that represented by the figure in the 'Fossil Flora.' Compare with the leaves of the recent *Aneimia fraxinifolia*. *Glossopteris cuneata*, L. & H. tab. 155, a two-leaved form referred by Lindley to *Otopteris*, from the same locality, may be the same species, young or imperfect. There are, however, a small specimen in the York Museum with four small oval leaves which appears to be distinct, and a leaf of larger size in the Museum at

Cambridge, of an oval shape, with areolate venation somewhat resembling *Sagenopteris Göppertiana* of De Zigno, pl. 22. figs. 1, 2, which is a fossil of the Veronese.

Lign. 13.



Lign. 14.

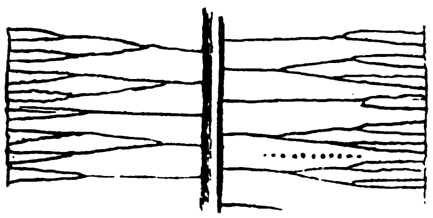


*Marzaria Simpsoni*, Ph. [Lign. 13 and 14.]

Frond terminated by eight connate leaves with undulated edges and what appears to be a midrib. Venation not traceable in the specimens seen. This appears to be certainly a fern, probably allied to *Glossopteris*; it agrees with the genus *Marzaria* of De Zigno, except that no distinct venules appear.

In lower sandstone and ironstone, Hawsker. Whitby Museum. The Lignograph 13 is from my drawing in 1825, the other (14) slightly corrected in 1873. The figure given by Young and Bird, pl. 1. f. 3, 2nd ed., is not quite accurate, and shows no midrib. Mr. Simpson has found several other specimens in the Whitby Museum, and obliged me with sketches of all.

Lign. 15.



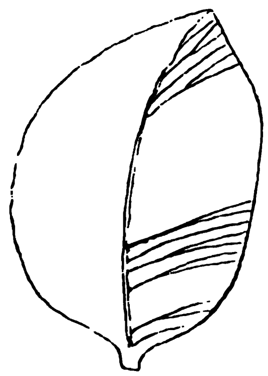
*Tæniopteris major*, L. & H. tab. 92. (*Aspidites Williamsonis*, Göpp. *Aspleniopteris Nilssoni*, Ph. 1829.) [Pl. VIII. fig. 4; Lign. 15.]

Frond broad, entire, petiolate; veins once or twice furcate, set perpendicularly to the midrib.

The analogy with the recent *Scolopendrium* is obvious, both as to general figure and characteristic venation. The fructification, as yet unknown, should be looked for in the situation marked by the dotted line.

From middle shale, Gristhorpe.

Lign. 16.



*Tæniopteris ovalis*, Sternb. (*Otopteris ovalis*, L. & H. tab. 110.) [Lign. 16.]

Leaf petiolate, broad, oval, pointed, with simple or furcate veins diverging at obtuse angles from a distinct midrib.

From middle shale, Gristhorpe, rare.

*Tæniopteris vittata*, Br. tab. 82. f. 1–4. (*Scolopendrium solitarium*, Ph. 1829.) [Pl. VIII. fig. 5.]

Leaf solitary, narrow, entire, petiolate, with strong veins set at right angles to the midrib, variously furcate. The figure in Pl. VIII. gives the general aspect and petiole of the leaf, somewhat reduced in size. The venation is like that of *Tæniopteris major*.

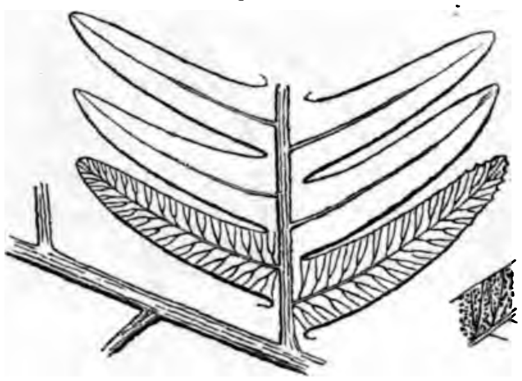
From middle shale, Gristhorpe, and lower shale, Saltwick.

*Aspidium Wallichianum*, an Indian fern, is mentioned by Lindley as hardly distinguishable from this fossil.

*Pecopteris*.—In considering this large conventional genus, Brongniart employed subdivisions founded on the form and structure of the pinnulæ, examples of fructification being then and still somewhat rare. Other writers have endeavoured to introduce the classification adopted for recent ferns, chiefly founded on the fructification—as yet, however, it appears, with only partial success. I have found the following method of grouping similar forms convenient:—

§ 1. *Pteroideæ,* Brongniart. Pinnulæ attached by the whole base, usually connate; midrib straight, continuous; veins springing from it at an angle usually exceeding 45°, each furcate, rarely twice furcate.

Lign. 17.



*Pecopteris insignis,* L. & H. tab. 106. [Lign. 17.]

Frond ample; pinnæ alternate, approximate; pinnulæ long, narrow, connate, tapering, with edges usually entire; veins about 20.

From the middle shale, Gristhorpe.

Lign. 18.

*Pecopteris denticulata,* Brongn. tab. 98. f. 1, 2. [Lign. 18.]

Differs from *P. insignis* only by the uniformly denticulated margin and fewer veins, these being about 12.

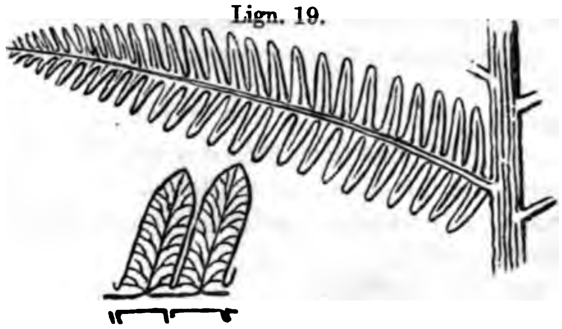
From the middle shale, Gristhorpe.

*Pecopteris ligata,* Ph. [Pl. VIII. fig. 14.]

Frond composed of opposite or alternate long, narrow pinnæ; pinnulæ triangular, arched connate, entire, with about 12 veins.

In middle shale, Gristhorpe.

Lign. 19.



*Pecopteris Phillipsii*, Brongn. tab. 109. f. 1. [Lign. 19.]

Frond ample; pinnæ lanceolate, approximate, alternate; pinnulæ obtuse, narrow, entire, close, sessile, connate; veins 8, furcate; midrib strong.

From the Scarborough coast. In the Yorkshire Museum, according to Brongniart.

§ 2. *Cæspitosæ*. Frond tufted, pinnate; veins furcate, from a straight midrib. (*Laccopteris*, De Zigno.)

*Pecopteris polydactyla*, Leck. Geol. Journ. vol. xx. pl. xi. fig. 1.

Stem ribbed, terminated by a crown of long, narrow, connate fronds; pinnulæ narrow, sessile, close, connate, a little arched. Fructification dorsal, consisting of about 12 pairs of sori.

From lower shale and ironstone at Haiburn Wyke.

Fine specimens in the Leckenby Collection at Cambridge, with pinnæ 8 inches long. Eight pinnæ are distinctly seen in this delicate fossil (there may have been more).

Lign. 20.

*Pecopteris cæspitosa*, Ph. [Pl. VIII. fig. 10; Lign. 20.]

Stem ribbed, terminated by a crown of long, narrow, connate fronds; lower pinnulæ broad,

short, decurrent, upper ones long, narrow, sessile, connate, arched. In one specimen 18 fronds can be counted. The species appears to have been larger than *P. polydactyla*, and to have had stronger stems.

In middle shale, Gristhorpe.

The figures given above represent fern fronds lying as if they belonged to a cæspitose fern of something larger proportions than *Pecopteris polydactyla*; but it is not certain that they correspond with *Pec. cæspitosa*. The fructification has left conspicuous outlines of the sori, agreeing in situation with Polypodiaceous ferns.

In ironstone, lower shale, Haiburn Wyke.

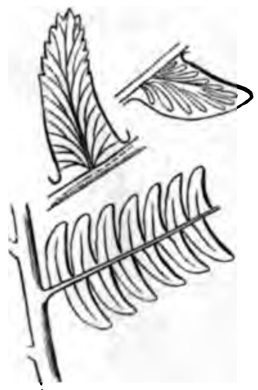
§ 3. *Brachypteridæ*. Pinnulæ usually attached by the whole base; midrib more or less flexuous; veins springing from it at an acute angle, furcate or bifurcate, and meeting the edge almost perpendicularly.

*Pecopteris Whitbiensis*, Brongn. tab. 109. figs. 2–4; not *Pec. Whitbiensis*, L. & H. tab. 134. (*Pecopteris hastata*, Ph. 1829. *Pecopteris tenuis*, Brongn. tab. 110. f. 3, 4.) [Pl. VIII. fig. 17.]

Frond ample, with broad striated rachis; pinnæ elongate; pinnulæ close, arched, broad, subtriangular, sessile, connate, the lowest enlarged; veins furcate or bifurcate, diverging from a somewhat flexuous midrib.

From lower sandstone and shale, Haiburn Wyke and Whitby.

Lign. 21.

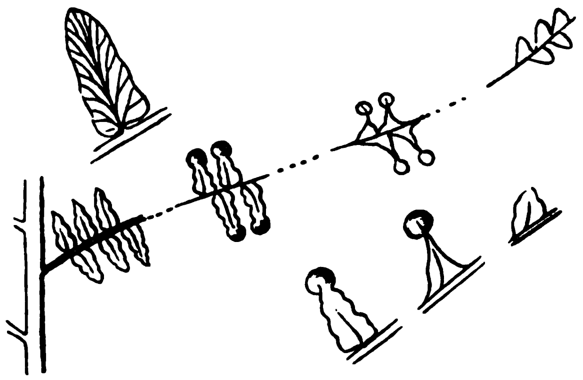


*Pecopteris dentata*, L. & H. tab. 169, not Brongn. (*Pecopteris Huttoniana*, Presl.) [Lign. 21.]

Frond expanded; pinnæ usually alternate, narrow, very approximate; pinnulæ about 30, closely set, sessile, the lower ones dentate toward the apex, the upper ones shorter, not dentate, with indications of radial fructification; veins mostly furcate, diverging at acute angles from the midrib.

From middle shale, Gristhorpe and Cloughton Wyke.

Lign. 22.



*Pecopteris Lindleyana*, Presl. (*Neuropteris arguta*, L. & H. tab. 105.) [Lign. 22.]

Frond expanded; pinnæ approximate, elongate; pinnulæ slightly contracted at the base, close, oblong, pointed, undulated at the edge. Venation diverging from the midrib in five pairs, which are forked toward the margin. Fructification terminal; sori single, large, hemispherical, concave beneath, nourished by the midrib. The round sori appear sometimes detached (but *in situ*) by removal of the narrow connexion.

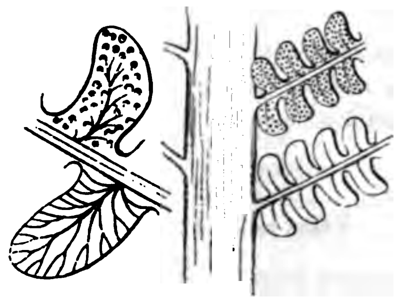
In middle shale, Gristhorpe, Cloughton Wyke. In the Leckenby Collection.

*Pecopteris curtata*, Ph. [Pl. VIII. fig. 12.]

Frond expanded; pinnæ narrow, approximate; pinnulæ sessile, with undulated edges, set at 90° to the axis; veins few, once or twice forked, diverging from a somewhat flexuous midrib. The pinnules are often granulated at the bark. This is believed to be distinct from *P. Williamsonis*.

From the lower shale, Stainton-dale cliff, and from the middle shale, Gristhorpe.

Lign. 23.



*Pecopteris Williamsonis*, Brongn. tab. 110. f. 1, 2. (*Pecopteris curtata*, in part, Ph. 1829. *Acrostichites Williamsonis*, Göpp.) [Pl. X. fig. 7; Lign. 23.]

Frond expanded, with thick rachis; pinnæ narrow, long, diverging at an angle of 70°;

pinnulæ short, obtuse, arched, approximate, sessile, connate, at right angles to the axis; veins 5 or 6, diverging from a somewhat flexuous midrib, once or twice forked. Fructification in round small sori.

From Cloughton Wyke, in middle shale.

### § 4. *Rarivenæ*. Pinnulæ short, with few furcate veins.

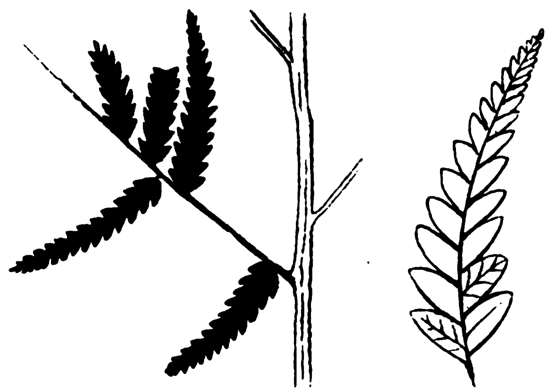
*Pecopteris acutifolia*, L. & H. tab. 157. f. 2.

Frond lanceolate; pinnæ frequent; pinnulæ short, ovato-acuminate, sessile, connate; veins few, furcate; midrib straight.

Differs from *Pecopteris exilis* only in the form of the pinnule.

In upper shale, under Red Cliff (Dr. Murray).

Lign. 24.



*Pecopteris serrata*. (*Sphenopteris serrata*, L. & H. tab. 148.) [Lign. 24.]

Frond ample, ramose; pinnæ divergent, elongate; pinnulæ long, very narrow, deeply cut into short, connate, pointed leaflets; veins few; midrib straight.

In middle shale, Cloughton.

*Pecopteris exilis*, Ph. (*Pecopteris obtusifolia*, L. & H. tab. 157. f. 1, tab. 158.) [Pl. VIII. fig. 16].

Frond ample; pinnæ long, narrow; pinnulæ short, obtuse, sessile, connate; veins few, furcate; midrib straight. Fructification dorsal, consisting of a few sori in two rows.

In middle shale, Gristhorpe.

### § 5. *Neuropterideæ*. Veins radiating toward the end of the pinnule.

*Pecopteris lobifolia*, Ph. (*Neuropteris lobifolia*, 1829.) [Pl. VIII. fig. 13.]

Frond ample; pinnulæ alternate, contracted at the base, thence expanded and undulated; the lowest basal pinnule much enlarged. Venation diverging at acute angles from a somewhat obscure flexuous midrib.

From the middle shale, Gristhorpe.

*Pecopteris undulata.* (*Neuropteris undulata*, L. & H. tab. 83.)

Frond ample, loosely branching; pinnæ distant, long; pinnulæ distant, alternate, obtuse, more or less undulated, those near the base small, oval; further on they become much larger, and are somewhat expanded at the base. Venation furcate.

From the middle shale, Gristhorpe.

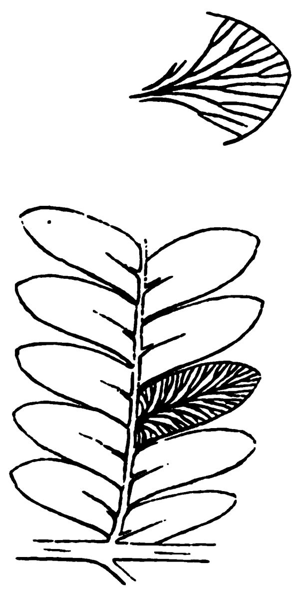
*Pecopteris inconstans*, Ph. (*Pecopteris lobifolia*, L. & H. tab. 179.)

Frond ample; pinnæ approximate, elongate; pinnulæ sessile, connate in the proximal, separate in the distal parts; basal pinnulæ enlarged, distal pinnulæ undulated. Venation flexuous, furcate. Three forms of pinnule appear on the same pinna.

From lower shale, Haiburn Wyke.

The three forms above noticed belong to one natural group, the two last-named possibly to one species.

Lign. 25.



*Pecopteris Haiburnensis*, L. & H. tab. 187. [Lign. 25.]

Frond ample, with delicate rachis; pinnæ approximate; pinnulæ oval, broad, sessile; veins mostly twice forked, diverging toward the apex of the somewhat flexuous midrib.

From the lower shale, Haiburn Wyke.

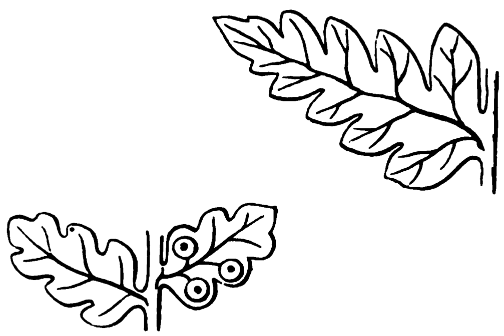
*Pecopteris recentior*, Ph. [Pl. VIII. fig. 15.]

Frond ample, with a thick rachis; pinnæ very long, approximate; pinnulæ 20–30, oval, obtuse, entire, sessile; veins once or twice forked, diverging from a flexuous midrib.

From the middle shale, Gristhorpe.

*Sphenopteris.*—To this genus various forms have been, by Brongniart, referred, which subsequent writers have endeavoured to place in different genera of recent ferns. There are two principal groups—one with short, more or less divided pinnulæ, sometimes approaching *Pecopteris*, the other with laciniate leaflets and the aspect of the recent *Hymenophyllum*. For convenience this distinction might be employed as generic.

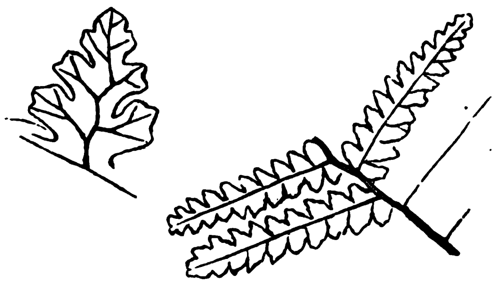
Lign. 26.



*Sphenopteris Murrayana.* (*Pecopteris Murrayana*, Brongn. tab. 126. f. 1–5; Leck. G. J. vol. xx. pl. xi. fig. 2. [Lign. 26, from Brongniart.]

This rather doubtful species appears to be truly a *Sphenopteris*. Leckenby represents it in partial fructification, and regards the fertile part of the frond as being *Tympanophora racemosa* of Lindley.

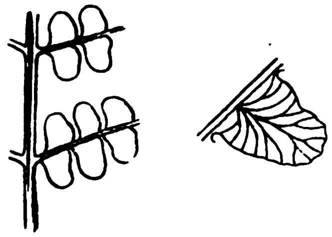
Lign. 27.



*Sphenopteris athyroides.* (*Pecopteris athyroides*, Brongn. tab. 125. f. 3. *Sphenopteris*, Zign.) [Lign. 27.]

A specimen of this singular fern, described by Brongniart, is said to have been from Saltwick and to be preserved in the Yorkshire Museum. The pinnulæ appear to have been attached by the whole base, and to have been connate.

Lign. 28.

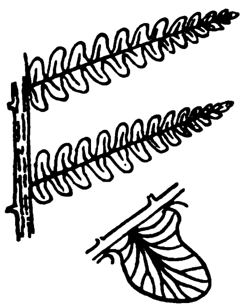


*Sphenopteris modesta*, Leck. G. J. vol. xx. pl. x. f. 3. [Lign. 28.]

Frond expanded, with slender stem and branches; pinnæ subopposite, frequent, close, long. and narrow; pinnulæ obtuse, sessile at right angles to the axis, a little crenulated at the edge, and a little expanded on the distal part of the base; veins few, mostly furcate.

From the middle shale at Gristhorpe and Cloughton (Leckenby).

Lign. 29.



An allied species, or variety of this [Lign. 29], with distinctly auriculate pinnulæ, occurs at Stainton dale.

Lign. 30.

*Sphenopteris affinis*, Phil. [Lign. 30.]

Frond bipinnate; pinnæ alternate, frequent, tapering; pinnulæ separate, subpetiolate, alternate or subopposite, expanded, subtrilobate, crenulated. Venation composed of a few mostly

furcate, fine veins, diverging almost in pairs from a fine mid vein. The lowest pinnule is not enlarged, the stipe is a little flexuous.

From ironstone in lower shale, Haiburn Wyke (my Collection).

Lign. 31.

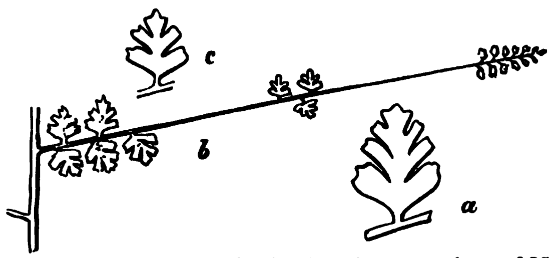

Fig. 1. Pinnulæ, with sori, nat. size. Fig. 2. Pinnulæ, with sori, enlarged, $\frac{2}{1}$. Fig. 3. Thecal mass. Fig. 4. Pinnulæ of full ordinary size. Fig. 5. Pinnule, enlarged, $\frac{4}{1}$. Fig. 6. Basal pinnulæ, enlarged, $\frac{2}{1}$. Figs. 7, 8. A somewhat different form of pinnula.

*Sphenopteris socialis*, Ph. [Lign. 31.]

Frond bipinnate; pinnæ narrow, tapering; pinnulæ approximate, subpetiolate, mostly 5-lobed, crenate, the basal lobes of the proximate pinnulæ expanded and deeply cleft. Fructification marginal, the leaf-edge being apparently deflected. Usually three spore-masses; but the basal pinnula appears to have had every lobe fructiferous, as in *Sph. nephrocarpa*, Bunb.

In ironstone and shale, lower series, Haiburn Wyke, Saltwick.

Lign. 32.




*a*. Pinnula from a sandstone specimen, magnified. *b*. Pinna from a specimen of Mr. Bean's in ironstone. *c*. Pinnula from the same, magnified.

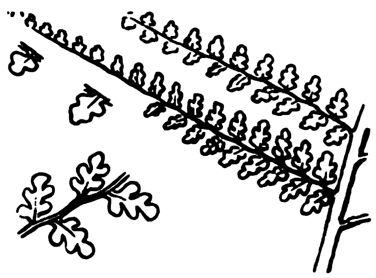
*Sphenopteris dissocialis*, Ph. [Lign. 32.]

Frond bipinnate, ample, with slender stem; pinnæ very long and narrow; pinnulæ petiolate

separate, short, deeply cleft into crenulated lobes. The petiolate attachment is remarkable in specimens from the Bean Collection, in the Yorkshire Museum, named by him, but not correctly, *Sph. stipata*.

In lower sandstone, Haiburn Wyke, Saltwick.

Lign. 33.

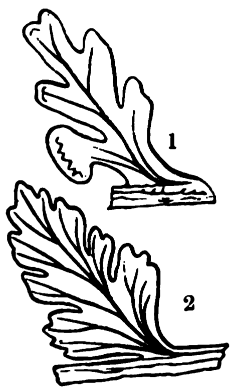


*Sphenopteris quinqueloba*, Ph. [Lign. 33.]

Frond bipinnate; pinnæ long, narrow, with a slightly flexuous axis; pinnulæ separate, petiolate, 5-lobed, changing to 3-lobed toward the apex of the pinna. Brongniart (tab. 126. fig. 5) assigns a form like this to his very unlike *Pecopteris Murrayana*.

From lower shale, Haiburn Wyke and Stainton-dale cliff.

Lign. 34.



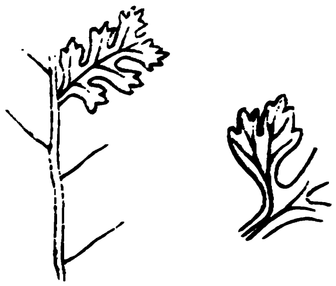

Pinnulæ magnified four times: 1, with fructification; 2, ordinary form.

*Sphenopteris hymenophylloides*, Brongn. tab. 56. f. 4. (*Sph. stipata*, Phil. 1829.) [Pl. X. fig. 8; Lign. 34.]

Frond bipinnate; pinnæ long, narrow, approximate, with a straight axis; pinnulæ connate, deeply cleft into crenated lobes, the lowest of which, on the distal edge, is usually somewhat enlarged. Fructification marginal; usually one large sorus at the end of the upper inner lobe (fig. 1). Compare with *Davallia canariensis*.

In lower shale, Haiburn Wyke.

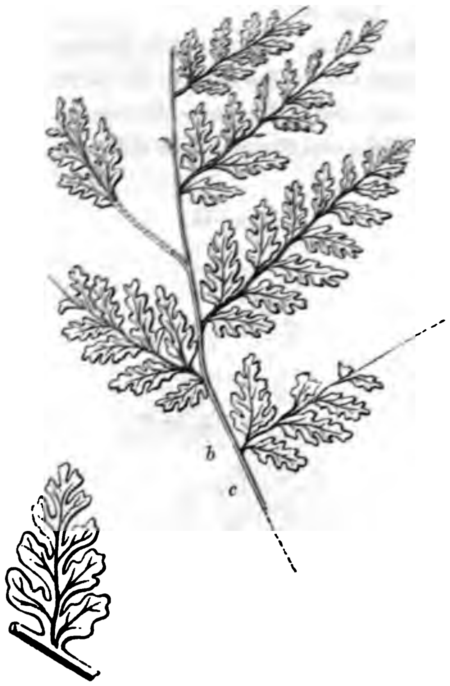
Lign. 35.



*Sphenopteris crenulata*, Brongn. tab. 56. f. 3. [Lign. 35.]

Frond bipinnate; pinnæ lanceolate; pinnulæ connate at the base, bi- trilobate at the summits. From lower shale, Haiburn Wyke.

Lign. 36.



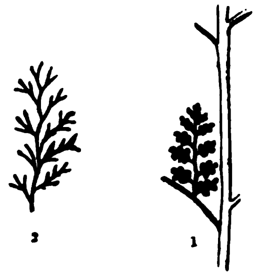
*Sphenopteris arbuscula*, Phil. [Lign. 36.]

Frond bipinnate, with slender stem and branches; pinnæ rather distant, ovato-lanceolate, with somewhat flexuous axis; pinnulæ distinct, oval, deeply cleft into crenulated lobes, midrib flexuous. The outer or upper basal pinnula (*b*) much larger than the lower one (*c*).

From the lower shale, Haiburn Wyke and Stainton-dale cliff (my Collection).

Compare with the recent *Aspidium atomarium* and the figures of *Pecopteris Murrayana*, Brongniart, tab. 126. f. 1–5.

Lign. 37.



1. Pinnula, natural size. 2. Extremity of pinna with only the principal veins preserved.

*Sphenopteris arbuscula*, var. [Lign. 37.]

In this case the frond is tripinnate, the pinnula being entirely pinnatifid, and the lobes decomposed into petiolate quinquepartite leaflets, set on a flexuous axis. It may be from a lower part of the frond.

Lign. 38. Lign. 39.

*Sphenopteris denticulata*, Brong. tab. 56. f. 1. (*Sphenopteris arguta*, Lindley, tab. 168.) [Lign. 38 & 39.]

Frond bipinnate, pinnæ with slightly geniculate axis; pinnulæ with diverging narrow deeply cut lobes, which are bifid or trifid at the extremities, analogous to *Sph. hymenophylloides* [Lign. 39], but with a difference of form in the pinnulæ of the two allied species, as may be seen by comparing the lignographs given above.

In middle shale, Gristhorpe. In lower shale, Haiburn Wyke.

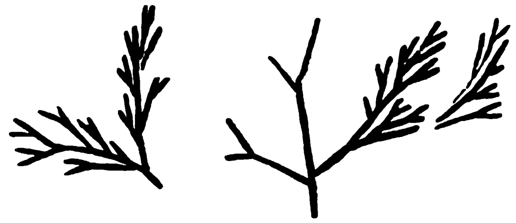
*Sphenopteris Williamsoni*, Brongn. (*Sphenopteris digitata*, Phil. 1829.) [Pl. VIII. fig. 6.]

In middle shale, Gristhorpe.

*Sphenopteris muscoides*, Phil. [Pl. X. fig. 10.]

In lower sandstone, Haiburn Wyke.

Lign. 40.



*Sphenopteris Jugleri*, Leck. G. J. vol. xx. [Lign. 40.]

The minutely dissected character of the frond is well seen in Mr. Leckenby's specimens at Cambridge, from which the above sketch was taken.

In lower shale, Stainton dale.

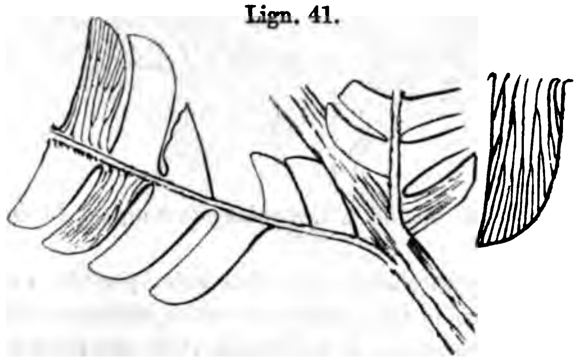
*Ctenis falcata*, L. & H. tab. 103. [Pl. VII. fig. 21.] (*Cycadites sulcicaulis*, Ph. 1829.)

Frond ample; rachis thick, sulcate; leaflets long, with parallel entire edges attached by their widened approximate bases; venation parallel, simple or once furcate, curved at their origin from the rachis.

In middle shale, Gristhorpe.

The place of this plant is disputed between Zamiaceæ and Filices. It has not been seen branched; and the terminations of the leaflets are rare.

Lign. 41.



*Odontopteris Leckenbyi*, Zign. [Lign. 41.] (*Ctenis Leckenbyi*, Bean, G. J. vol. xx. pl. x. f. 1 *a*.)

Frond bipinnate; rachis thick, sulcate; pinnæ formed of short, broad, arched pinnulæ, attached by their widened approximate basis to a slender axis; venation subparallel, usually twice forked (5 veins and 20 terminal venules).

In middle shale, Gristhorpe. Rare in the Leckenby Collection.

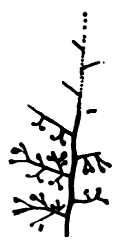
The place of this plant in classification is doubtful.

*Fructification of Fossil Ferns.*—On this subject a considerable amount of knowledge is gathered, but not as yet carefully discussed. The type common among polypodiaceous living ferns is the most frequent (see *Phlebopteris crenifolia*); a different

arrangement (see *Sphenopteris*) resembles that of *Davallia*; and a third is seen in *Pecopteris Lindleyana*.

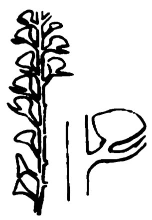
Some of the fertile pinnæ, seen separately, have been named *Tympanophora simplex* (L. & H. tab. 170 A), which seems to be of a polypodioid type, and *T. racemosa* (L. & H. tab. 170 B), which is referred by Leckenby to *Pecopteris Murrayana* (probably a *Sphenopteris*) of Brongniart. Bunbury figures and describes fructification like that of *Sphenopteris hymenophylloides* under the title of *Sph. nephrocarpa*, and refers for comparison to *Thyrsopteris elegans*, from Juan Fernandez.

Lign. 42.



Sphenopterioid.
*Tympanophora racemosa.*

Lign. 43.



Polypodioid.
*Tympanophora simplex.*

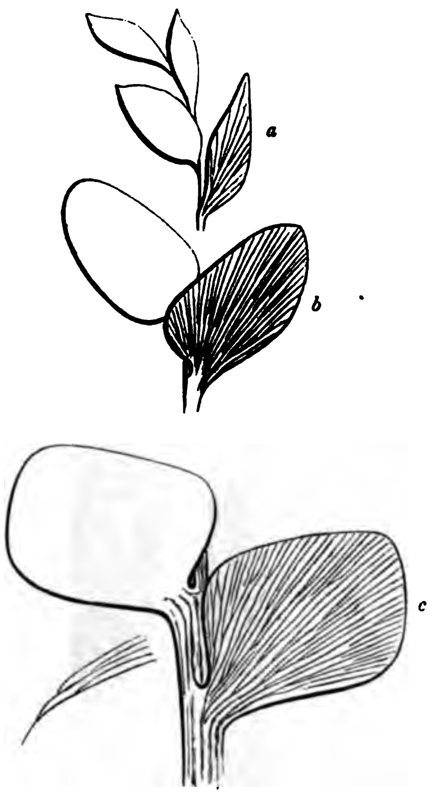
*Tree-Fern Stem.*—The only example which has occurred to me, represented below, was taken by myself from a soft bed of sandstone in the middle shale of Gristhorpe :—

Lign. 44.

## CYCADACEÆ.

The passage from Ferns to Cycadaceæ is by a more easy gradation among fossils than among living races. The first group here noticed among Cycadaceæ has, in the general air of the fronds and the method of venation, enough of resemblance to Filices to have induced Lindley to place it among them, under the title of *Otopteris*; they certainly belong to *Otozamites* of Bronn, or *Palæozamia* of Brongniart.

Lign. 45.




*a.* Upper leaflets. *b.* Middle leaflets. *c.* Lower leaflet.

*Otozamites Beanii.* (*Otopteris Beanii*, L. & H. tab. 44.) [Lign. 45.]

Frond long, narrow, composed of many broad smooth leaves, partly covering each other, which spring from the upper surface of a striated stem.

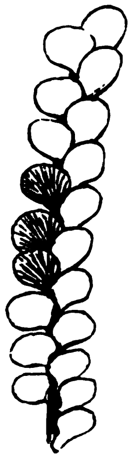
Venation diverging from the proximal part of the base of the leaf, and forked into about 100

divisions near the edge. The leaves are nearly circular in the lower, oval in the middle, and lanceolate in the upper part of a frond 20 inches long. In the Leckenby Collection.

Leaves corresponding in arrangement and form to the upper part of *Cyclopteris Beanii*, are represented in the 'Fossil Flora,' tab. 208, under the title of *Otopteris acuminata*, var. *brevifolia*. Another figure, by Leckenby, G. J. xx. pl. x. fig. 2, entitled *Otopteris mediana*, presents considerable resemblance.

From middle shale, Gristhorpe. Leckenby Collection and my Cabinet.

Lign. 46.

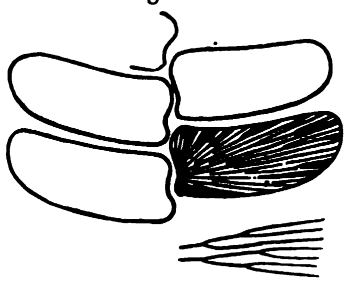


*Otozamites tenuatus*. (*Otopteris tenuata*, Bean, MS.) [Lign. 46.]

Frond long, narrow; leaves nearly circular, crowded; venation radial, unequal.

In lower sandy shale, Haiburn Wyke. Compare *Pecopteris Desnoyersii*, Br. tab. 129. f. 1. from the oolite of Mamers.

Lign. 47.



*Otozamites parallelus*, Ph. [Lign. 47.]

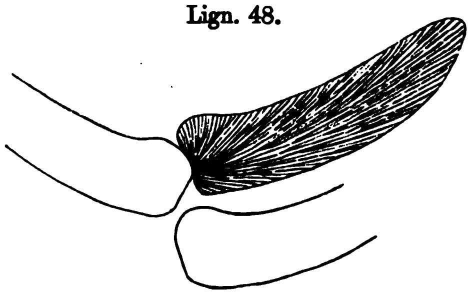
Frond very long, narrow, composed of many oval slightly obtuse leaves two or three times as long as broad, set perpendicular to the rachis; venation radiating from the proximal part of the base of the leaf, furcate, and dividing to about 40 venules toward the edge. The specimen figured is above the average size.

From the lower sandstones near Whitby.

In my Collection, a specimen 8 inches long contains 25 leaflets on each side, the breadth of the frond not more than 1¼ inch.

The Yorkshire fossils have usually been referred to *Otopteris obtusa*, L. & H. tab. 128, which was described from two specimens (obtained from the lias of Dorset) in the Oxford Museum. On comparison, however, these specimens are found to have the leaves much narrower in proportion, and set more obliquely on the rachis. In outline, the leaflets of *O. parallelus* agree nearly with *Filicites Reglei*, Br. (Ann. d. Sci. Nat. vol. iv. tab. 19. f. 2.)

Lign. 48.



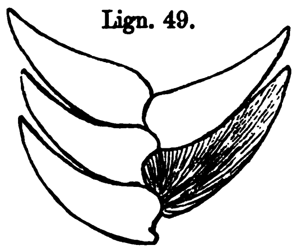
*Otozamites obtusu.* (*Otopteris obtusa*, L. & H. tab. 128. *Palæozamia Bucklandi*, Br. G. J. 2nd ser. vol. i. pl. vii. f. 2.) [Lign. 48.]

Frond narrow, composed of arched obtuse leaves (three or four times as long as broad) set obliquely on the rachis. Veins numerous, radiating from the proximal edges of the base, furcate.

From the lower shale, Haiburn Wyke.

The names above quoted refer to the same specimen, which was taken from near the base of the lower lias at Axminster, and is now in the Oxford Museum. Brongniart gives a figure (Ann. d. Sci. Nat. tome iv. pl. 19. f. 3) from a French specimen, taken from the oolite, larger but not so perfect as the English type. In the York Museum is a frond of large size, 9½ inches long, with 25 leaflets 1½ inch long. The terminations of the leaflets are a little oblique, the upper edge least obtuse.

Lign. 49.

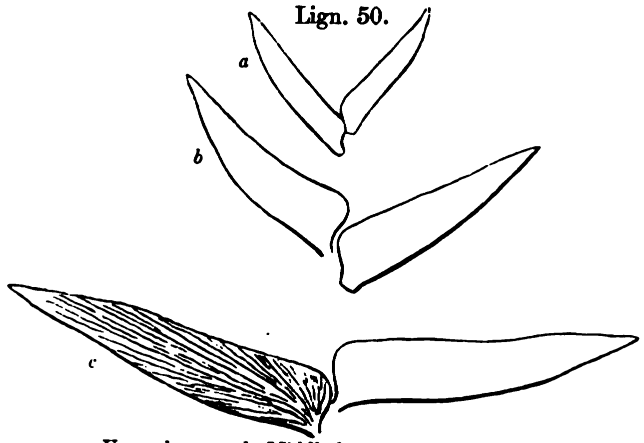


*Otozamites graphicus.* (*Otopteris graphica*, Leck. from Bean's MS. G. J. vol. xx. pl. viii. f. 5.) [Lign. 49.]

"Frond very long; leaflets cuneiform, oblique, their bases expanded, apices subacute." Leckenby, in G. J. vol. xx. pl. viii. f. 5. A specimen in the British Museum is 2 feet long.

In lower shale, Haiburn Wyke.

Lign. 50.




*a.* Upper leaves. *b.* Middle leaves. *c.* Lower leaves.

***Otozamites acuminatus.*** **(*Otopteris acuminata,* L. & H. tab. 132.) [Lign. 50.]**

**Frond ample; leaflets acute, subauriculate; venation radiating from the proximal part of the base. This plant is one of the largest of those found on the Yorkshire coast.**

**From the middle shale, Gristhorpe, and lower shale, Haiburn.**

Lign. 51.

***Otozamites gramineus,*** **Ph. [Pl. X. fig. 2; Lign. 51.]**

**Frond ample (3½ inches wide); leaves very long, arched upwards, subauriculate; venation strongly marked, radiating from the proximal edge of the base; surface striate.**

**In lower sandstone, Whitby, Saltwick. York Museum, Leckenby Collection, my Cabinet.**

**The figure given above represents the terminal portion of the frond.**

***Otozamites lanceolatus,*** **Ph. [Pl. X. fig. 3, lower aspect.]**

**Frond long and large, with a strong striated rachis; leaflets lanceolate, with acute apices and rounded bases; venation radiating at its origin, becoming afterwards parallel to the lower margin. This somewhat resembles *Zamites gigas,* L. & H. tab. 165, in which, however, the venation appears different from what is usual in the Otozamids.**

**In the lower sandstone near Whitby. York Museum.**

*Otozamites latifolius*, Ph. [Pl. X. fig. 1.]

Frond ample; rachis slender; leaflets broad, acute, contracted and subauriculate at the base; venation delicate, radiating to the upper margin.

A rare species from the lower sandstone of Saltwick. York Museum.

Lign. 52.

*Otozamites gracilis*, Ph. (*Otopteris lanceolata*, Leck. from Bean's MS.) [Lign. 52.]

"Frond tapering, contracting abruptly at the apex, leaflets long, slender, their apices acute." Leck. G. J. vol. xx. pl. viii. f. 4. A specimen in the Cambridge Museum, 12 inches long, has 44 leaflets. The venation approaches to parallel, not radiating, which brings it near to *Pterophyllum*.

In lower shale, Haiburn Wyke.

*Williamsonia gigas*, Carruthers, Linn. Trans. vol. xxvi. p. 680. (*Zamites gigas*, L. & H. tab. 165. Williamson, Linn. Trans. vol. xxvi. t. 52, 53.) [Pl. XXIV.; Lign. 53.]

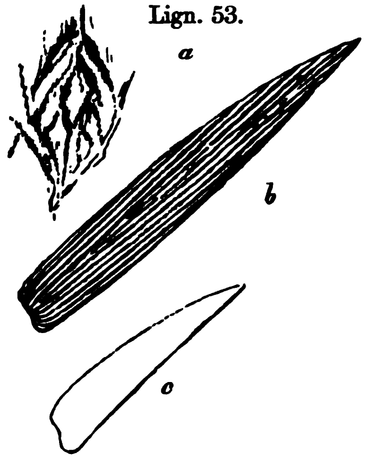
Frond very long; leaflets lanceolate, pointed, contracted at the base; venation at first a little divergent, afterwards subparallel to the margin.

The fructification of this plant is the subject of an elaborate memoir by Professor Williamson in the Transactions of the Linnean Society (vol. xxvi.), who has, apparently with success, restored from many fragments the general aspect of the male blossom, and the carpellary disk with twin ovules of the female. My sketches on Pl. XXIV. (made in 1825) will give a fair notion of some of the important parts. The two upper and two lower figures represent, in Professor Williamson's view, "verticils of enlarged bracts" of the male in different aspects. These bracts enclose a pyriform axis within the circle of cells (upper left-hand figure); this axis supperted parts not seen in these specimens, and was sheathed by a radiating structure supposed to have been antheridious.

The middle figure is the "carpellary disk" formed round the central axis by the coalescence of a single verticil of ovule-bearing bracts.

The specimens are in the Whitby Museum. The striated shading, which appears on the edges of some bracts, is supposed to represent no part of this structure; it occurs, however, in a specimen in my cabinet bordering what seem to be two connate bracts or scales.

Lign. 53.



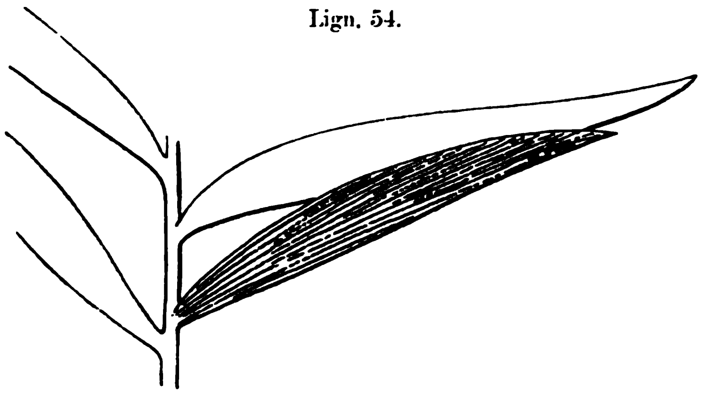

*a.* Rhomboidal leaf-scar from the impression of a stem in ironstone. *b.* Leaflet in the middle of the frond. *c.* Leaflet in the lower part of the frond.

The frond figured by L. & H. tab. 165, under the title of *Z. gigas*, was not found with any of the portions of the flower or fruit.

Mr. Carruthers adds *Pterophyllum pecten* and *Pt. pectinoideum* of this work to the genus *Williamsonia.*

From the lower sandstone, Whitby.

Lign. 54.



*Zamites lanceolatus*, L. & H. tab. 194. [Lign. 54.]

Frond patent; rachis slender; leaflets very long, narrow, lanceolate, pointed, much con-

tracted at the base; venation subparallel to the borders. Compare with the *Dion edule* of Mexico.

In lower sandstone, Haiburn Wyke, Whitby cliff.

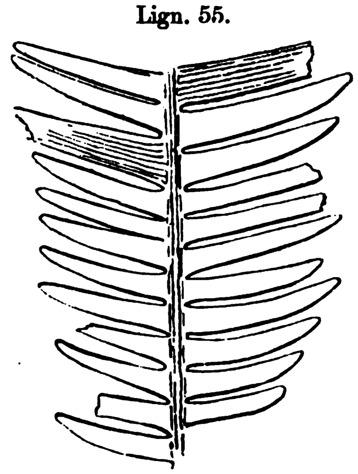
*Pterophyllum pectinoideum*, Ph. (*Zamites hastula* ?, Bean, MS. *Williamsonia hastula* ?, Carruthers. *Zamites Phillipsii*, Zigno.) [Pl. X. fig. 4.]

The usual aspect of the leaflets is marked by a few (5–7) interrupted striæ subparallel to the border; these are sometimes pitted. In one slightly carbonized specimen I find under the microscope the original epidermal surface perfect, with numerous (50 or 60) parallel concave pitted striæ and intermediate tubercled ridges, much as in some recent Conifers and in the other Cycadaceous plants of the Yorkshire coast when well preserved.

From lower shale and sandstone, Saltwick, Haiburn Wyke. York Museum, my Collection.

This species is not, as I supposed in 1829, to be referred to the Stonesfield fossil figured by Sternberg as *Polypodiolites pectiniformis*, by L. & H. (tab. 172) as *Zamia pectinata*, and by myself, G. of Oxf. Diagr. xxx. It may be, as Bean appears to have thought it, identical with what he names *Z. hastula*, *Williamsonia hastula* of Carruthers, *Zamites Phillipsii*, Zign. 1873. Regarding it as a *Pterophyllum*, it seems best to retain the ancient name for the present.

Lign. 55.



*Pterophyllum medianum*, Bean, MS. [Lign. 55]. (Leck. pl. 8. f. 3, not f. 2; Zigno, pl. 29. f. 4.)

Frond long; leaflets long, rounded at the extremity below, acute above, approximate at the base; venation parallel.

De Zigno figures a fine specimen (pl. 29. f. 4), 2¼ inches wide.

In middle shale, Gristhorpe.

*Pterophyllum pecten*, Ph. (L. & H. tab. 102; Leck. tab. 9. f. 4. *Williamsonia pecten*, Carruthers; Zigno, tab. 29. f. 1, 2.) [Pl. VII. fig. 22.]

Frond petiolate, long, and very narrow (½ an inch); leaflets obtuse, a little widened at the

base; venation parallel. The "flower," according to Leckenby, is composed of a central convex disk, surrounded by about 14 short striated leaves.

In the middle shale, Gristhorpe.

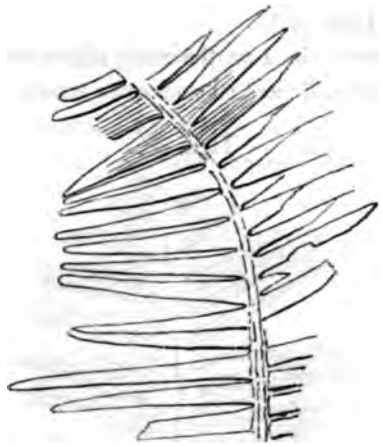
*Pterophyllum comptum*, Ph. (L. & H. tab. 66; Leck. tab. 9. f. 1.) [Pl. VII. fig. 20.]

Frond petiolate, long, lanceolate; leaflets broad, sometimes unequal, a little arched upward toward the end, approximate at the base; venation parallel, strongly marked; breadth 1–2 inches.

In a finely preserved impression of the lower surface there is an appearance of oval stomata and smaller dots between the rather sharply cut striæ. Rarely one or two veins are furcate.

In middle shale, Gristhorpe, and upper shale, White Nab.

Lign. 56.



*Pterophyllum angustifolium*, Bean; Leck. pl. 8. f. 2 (not f. 3). [Lign. 56.]

Frond expanded; leaflets very long, tapering, acute, perpendicular to the rachis, approximate at the base; venation parallel.

In middle shale, Gristhorpe.

*Pterophyllum tenuicaule*, Ph. [Pl. VII. fig. 19.]

Frond lanceolate, ample, with a slender rachis; leaflets perpendicular to the rachis, unequal, ending obtusely, approximate at the base; venation parallel, delicate. An elegant and rare species, 3 inches in breadth.

In middle shale, Gristhorpe.

*Pterophyllum Nilssoni*, L. & H. tab. 67. f. 2; Zigno, tab. 29. f. 3.

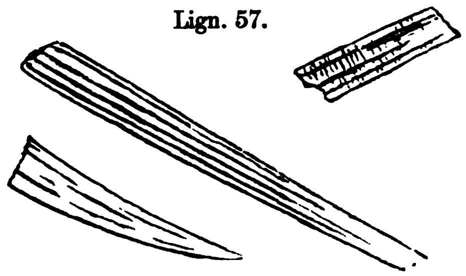
A narrow lanceolate frond, with unequal subquadrate leaflets conjoined at the base and more or less rounded at the extremity; venation parallel.

In the middle shale, Gristhorpe. Not *Aspleniopteris Nilssoni*, Ph. [Pl. VIII. fig. 4], which is probably a laciniated variety of *Tæniopteris major*, L. & H.

*Pterophyllum minus*, L. & H. tab. 67. f. 1; Leck. tab. 9. f. 2.

A very long, narrow frond, with bordering foliation divided into unequal portions; venation not seen. (De Zigno remarks that it is not *Pt. minus* of Brongn.; and Leckenby thinks it is a laciniated variety of *Tæniopteris vittata*.)

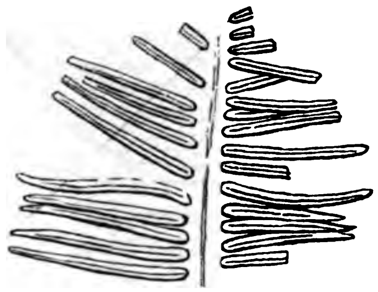
Lign. 57.



*Pterophyllum rigidum*, Ph. [Lign. 57.]

Several of these leaflets were obtained on the north side of Scarborough in the shales below Cornbrash: all are strongly furrowed; and on some cross striation is observed.

Lign. 58.



*Cycadites zamioides*, Leck. tab. 8. f. 1. [Lign. 58.]

Frond broad, abruptly contracted near the apex; pinnæ very slender, contracted at the base; a midrib (rachis apparently thick). It may be a Conifer.

In middle shale, Gristhorpe; in lower shale, Whitby cliffs.

### CONIFERÆ.

Wood of the true coniferous type probably occurs in the Sandstones, as well as rarely in the Oolites and plentifully in the Lias, where Mr. Witham detected its structure in thin sections of jet and tree-stems. Seeds referred to the affinity of *Araucaria* by Mr. Carruthers have been found in the sandstones and shales; and leafy stems of small size occur in the same situations.

*Araucarites Phillipsii*, Carruthers, Geol. Mag. vol. vi. p. 1. [Pl. X. fig. 5.]

*Brachyphyllum mammillare*, Br. V. F. tab. 1; L. & H. tab. 188.

From Haiburn Wyke and Whitby cliff, lower shale and sandstone.

Frond much branched; the branches irregularly dichotomous, covered with close, very short, thick, pointed leaves in quincunx. In the smaller branches the leaves are oval and form rows: on the larger stems they are rhomboidal. Lindley allies the plant to the Araucarian group of Coniferæ. Its general aspect is perhaps more cupressineous.

Lign. 59.

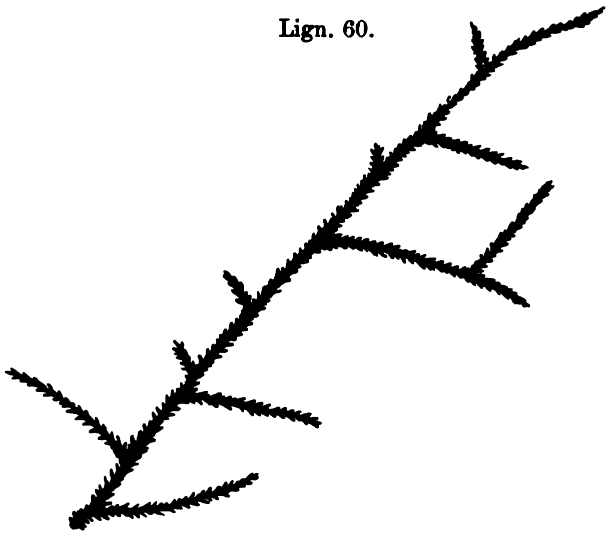
*Thuytes expansus*, Sternberg, F. der V. tab. 38; Lindley, F. F. t. 167. [Pl. X. fig. 11 Lign. 59.]

From Gristhorpe, in middle shale and in lower shale.

Irregularly branched, covered with short, ovato-acuminate, adpressed leaves.

It is possible that this plant, as given by Lindley, may not be really distinct from *Brachyphyllum mammillare*. The figure [Pl. X. fig. 11] in this work represents small terminal branches of a plant from Egton Moors and Saltwick, in lower shale. Each leaf, when magnified, shows a small circular mark within the margin near the apex, and a longitudinal stria.

Lign. 60.



*Brachyphyllum setosum*, n. s., Ph. [Lign. 60.]

Stem branching at obtuse angles, marked by alternate elongate cicatrices; leaves arranged

round an axis, lanceolate, pointed, small, short, crowded. The drawing is by Prof. Williamson from a specimen in his Collection.

Lower shale, Haiburn Wyke.

*Peuce Huttoniana*, Witham, tab. 14. f. 9, t. 15. f. 4 & 5.

From the upper lias, Whitby.

*Peuce Lindleyana*, Witham, tab. 9. f. 1–5, t. 15. f. 3.

From the upper lias, Whitby.

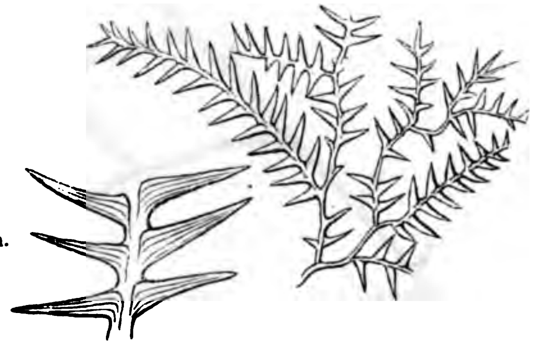
Lign. 61.

*Walchia Williamsonis*. (*Lycopodites uncifolius*, Phillips. *Lycopodites Williamsonis*, Brongniart; Lindley, F. F.) [Pl. VIII. fig. 3; Lign. 61.]

Frond firm, irregularly dichotomous, or spreading from a kind of axis, the branches set all round with upward-curved carinated leaves. Lindley admits the presence of stipulæ, and ranks the fossil with Lycopodiaceæ. Fructification terminal.

From the middle shale of Gristhorpe, Cloughton Wyke, &c.

Lign. 62.




*Cryptomerites divaricatus*, Bunbury, G. J. tab. 13. f. 4. [Lign. 62.]

From the middle shale at Gristhorpe. Phillips's Collection.

Frond feeble, expanded, much divided, divaricate; leaves set nearly at right angles to the branches, sessile, longitudinally striated. The leaves of *Cryptomeria japonica* are more spinose, and occupy the branches all round.

Lign. 63.

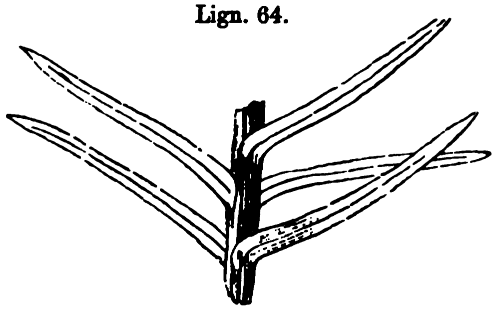

*Cryptomerites rigidus*, n. s., Phillips. [Lign. 63.]

Frond expanded, bipinnate; stem-branches alternate; leaves strap-shaped, obtuse, sessile; venation longitudinal.

From Gristhorpe, in middle shale. Williamson's Collection.

## TAXACEÆ.

Lign. 64.



*Taxites laxus*, Ph. [Pl. VII. f. 24; Lign. 64.]

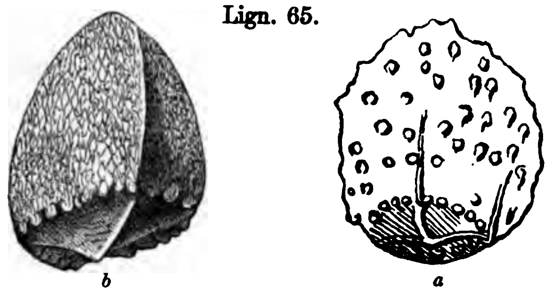
The figure is believed to represent a branch of a Conifer allied to *Taxus* by the form and mode of insertion of the leaves, which are long, narrow, and marked by a midrib.

From the middle shale, Gristhorpe.

A plant of similar form, but with shorter leaves, is found in the Whitby cliffs above the Dogger.

## PALMÆ ?

Lign. 65.




*Carpolithus Bucklandi*, L. & H. tab. 189. f. 3, 5. [Lign. 65 *a*.]
*Carpolithus conicus*, L. & H. tab. 189. f. 1, 2, 4. [Lign. 65 *b*.]

These fruits have three ridges on the base, with prolongations toward the apex, very distinct in *b*, slightly marked in *a*, not observed at all in another example of this last form. The surface of *b* is irregularly marked, something like the nut of *Cocos*; that of *a* is irregularly tubercled. Lindley refers them to Palmæ.

From the coralline oolite of Malton.

(*b*) Oxford Museum. (*a*) Leckenby Museum; this figure is from Lindley and Hutton, tab. 189.

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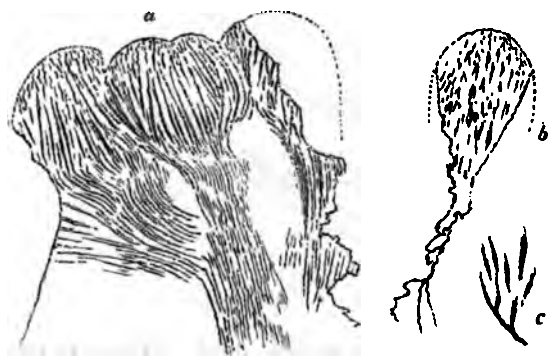
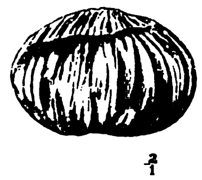
## INCERTÆ SEDIS.

Lign. 66.



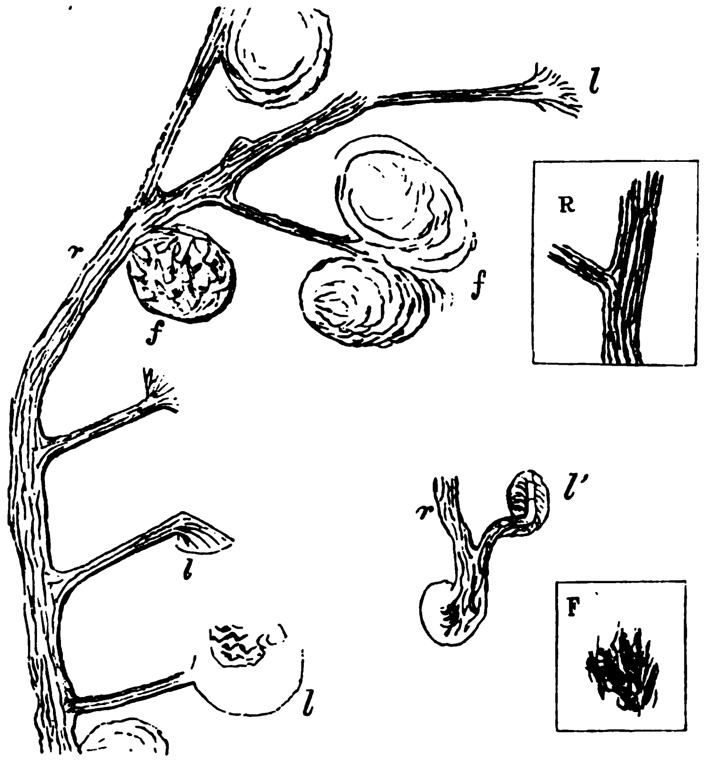

Lign. 67.




*Fructification.*—In Lignograph 66 is represented what may perhaps be of the nature of the fructification referred to under the title of *Sphæreda paradoxa*; but it is not connected to strongly fluted stems as that is. It is probably identical with the spherical body with longitudinal plications figured in Lignograph 67 (size twice

the original). This specimen shows principally a cast of the interior; in the upper part the carbonaceous substance remains. It is in my Collection. The larger specimen (Lign. 66) shows an impression of the outer surface at *b*, a small part of which is enlarged at *c*; the carbonaceous substance remains on the three approximate points *a*, which appear connected to a broad finely striated leafy expansion. It is in Prof. Williamson's Collection.

Lign. 68.




*r*. Rhizome, or stem and branches. R. Separate view of the striations on *r* &c. *l*, *l'*. Leaf expansions? at the ends of small branches. *f*. Supposed fructification, or circinate vernation. F. Separate view of the corrugations on *f*. The stem- or root-channelling is of the same character as that on *Ctenis falcata*.

*Sphæreda paradoxa*, L. & H. tab. 159. [Ph. Pl. VIII. fig. 2; Lign. 68.]

From middle shale, Gristhorpe. Rare, in my Collection.

This somewhat perplexing plant may possibly be the rhizome of a fern with young fronds in the circinate condition; a capsule-bearing analogue of *Isoëtes*, was the conjecture of Dr. Murray.

# CHAPTER XVI.

## ORGANIC REMAINS—ANIMALS.

### FORAMINIFERA.

FORAMINIFERA abound in the Oolites of Yorkshire, which in thin sections exhibit beautifully a few turbinated and discoid forms. They occur also in the marine clays, from the Lias upwards, and in the Chalk, but have not, it is believed, been systematically collected for study. *Cristellaria rotulata* is given by Morris from the Red Chalk and Speeton Clay of Yorkshire, *Globigerina cretacea* from the Red Chalk.

The following additional genera may be looked for in the Lias and Oolites:—*Bulimina, Flabellina, Frondicularia, Lituola, Marginulina, Nodosaria, Polymorphina, Rotalina, Spirolina, Vulvulina, Webbina**.

### SPONGIDA.

The following species occur in the upper part of the Chalk:—

| | | |
|---|---|---|
| *Cephalites Benettiæ*, Mant. | [Pl. I. fig. 4.] | Danes' Dike. |
| *Chenendopora convoluta*, Phil. | [Pl. I. fig. 6.] | ,, |
| *Coscinopora porosa*, Phil. | [Pl. I. fig. 8.] | ,, |
| *Coscinopora lævis*, Phil. | [Pl. I. fig. 8*a*.] | ,, |
| *Coscinopora pileolus*, Lamk. | [Pl. I. fig. 11.] | ,, |
| *Coscinopora globularis*, Phil. | [Pl. I. fig. 12.] | ,, |
| *Hippalimus radiciformis*, Phil. | [Pl. I. fig. 9.] | ,, |
| *Manon marginatum*, Phil. (*M. Reussii*, M'Coy, Ann. Nat. Hist. 1848.) | [Pl. I. fig. 5.] | ,, |
| *Manon osculiferum*, Phil. | [Pl. I. fig. 3.] | ,, |
| *Manon verruciferum*, Phil. | .......... | ,, |
| *Scyphia cribrosa*, Phil. | [Pl. I. fig. 7.] | ,, |
| *Siphonia terebrata*, Phil. | [Pl. I. fig. 10.] | ,, |
| *Spongia plana*, Phil. | [Pl. I. fig. 1.] | ,, |
| *Spongia capitata*, Phil. | [Pl. I. fig. 2.] | ,, |
| *Spongia ramosa*, Mant. t. 15. f. 11 | .......... | ,, |
| *Spongia alcyonoides*, Smith | .......... | ,, Brantingham. |

* See the valuable memoirs on this group of animals by Prof. R. Jones, Mr. Brady, and Prof. Williamson.

Additional forms were collected at Danes' Dike by Mr. Lee, and described and figured by him in the Mag. of Nat. Hist. 1839, under the following names:—*Siphonia clava, Spongia ampulla, S. catablastes, S. fastigiata, S. sepiæformis, S. spinosa, Udotea cancellata.*

Mr. Charlesworth regards many of the spongoidal forms as belonging to the same species; Mr. Toulmin Smith has scrutinized the internal structure of the Ventriculite forms, which are not frequent in the Yorkshire Chalk (Ann. Nat. Hist. 1848).

The Oolitic species are comparatively few:—

| | | | |
|---|---|---|---|
| *Manon foliaceum*, M'Coy, Ann. Nat. Hist. 1848 | ............ | Cor. Ool. | Malton. |
| *Scyphia cylindrica*, M'Coy | ............ | „ | „ |
| *Spongia floriceps*, Phil. | [Pl. III. fig. 8.] | „ | Hackness. |

## ACTINOZOA.

Corals of different genera occur in the Oolites, especially the Coralline Oolite: one only is yet known to me in the Chalk, one in the Speeton Clay, none in the Lias. The Oolitic Corals are frequently but not exclusively found in the upper part or at the very top of the deposit—though, as Mr. Leckenby has observed, not rising as an excrescence above the general surface, but rather filling far-separated hollows in it. The vicinity of Scarborough (Ayton, Hackness) and of Malton give the most satisfactory examples of limited "Coral reef," composed of *Isastrææ*, *Thamnastrææ*, Echinodermata, and shells of Mollusca at the top of the rock; while beds, more or less irregular, of *Montlivaltia* and *Thecosmilia* occur interstratified with foraminiferous Oolite and thin irregular partings of clay or oolitic marl. (Abbreviated references:—Edw. for Milne-Edwards, Brit. Fossil Corals, in Palæont. Soc. Memoirs; Dunc. for Duncan, Supplement to Brit. Foss. Corals, in the same work; Gold. for Goldfuss, Petrefactenkunde.)

### *Cretaceous and Neocomian Species.*

| | | |
|---|---|---|
| *Parasmilia centralis*, Mantell. | [Pl. I. fig. 13.] | Upper Chalk, Danes' Dike. |
| *Trochocyathus conulus*, Phil. | [Pl. II. fig. 1.] | Neocomian Clay, Speeton. |

### *Coralline-Oolite Species.*

| | | |
|---|---|---|
| *Stylina tubulifera*, Phil. …… | [Ph. III. fig. 6.] | Coralline Oolite, Malton. |
| *Montlivaltia dispar*, Phil. …… | [Pl. III. fig. 4.] | „ „ |
| *Thecosmilia cylindrica*, Phil. …. | [Pl. III. fig. 5.] | Inferior Oolite, Malton, Seamer. |
| *Rhabdophyllia Phillipsii*, Edw. pl. 15. f. 3. | ………… | Coralline Oolite, Hackness. |
| *Isastræa explanata*, Goldf. (*Astræa favosioides*, Phil.) | [Pl. III. fig. 7.] | Coralline Oolite, Old Malton. |
| *inæqualis*, Phil. ………. | ………… | „ „ |
| Calices unequal, of varied shape, often oval, with very thick walls. | | |
| *Thamnastræa arachnoides*, Park. | ………… | Coralline Oolite, Malton. |
| *concinna*, Goldf.; Edw. t. 18. f. 3. (*Astræa micrastron*, Phil.) | ………… | „ „ Ayton, Hackness. |
| *Gonioseris irradians*, Edw. t. 19. f. 1. (*Meandrina*, Phil.). | ………… | Coralline Oolite, Malton. |

### *Lower-Oolite Species.*

| | | |
|---|---|---|
| *Gonioseris angulata*, Dunc. t. 7. f. 1–5. | ………… | Millepore Oolite, Cloughton Wyke, Whitwell. |
| *Leckenbyi*, Dunc. t. 7. f. 6–9 | ………… | Millepore Oolite, Cloughton Wyke. |
| *Montlivaltia convexa*, Phil. …. | [Pl. XI. fig. 1.] | Inferior Oolite, Blue Wick. |

## ECHINODERMATA.

### Crinoidea.

### *Cretaceous and Neocomian Species.*

| | | |
|---|---|---|
| *Bourgueticrinus ellipticus*, Mill. . | ………… | Cliff at Danes' Dike. Rare. |
| *Marsupites ornatus*, Mill. …… | [Pl. I. fig. 14.] | „ „ Frequent. |
| *Pentacrinus Fittoni*, Aust. …… | ………… | Red Chalk, Speeton. |
| *annulatus*, Röm. …….. | ………… | Upper and Middle Clay, Speeton. |

### *Oolitic Species.*

| | | |
|---|---|---|
| *Millericrinus echinatus*, Goldf. .. | [Pl. III. figs. 9, 10.] | Coralline Oolite and Calc. Grit, Malton, Scarborough. |

### *Liassic Species.*

| | | |
|---|---|---|
| *Extracrinus Briareus*, Mill. sp. .. | ………… | Upper Lias, Saltwick, near Whitby. |
| *subangularis*, Mill. sp. p. 60 | ………… | Lower Lias with *Gryphites*, Redcar. |

| | | |
|---|---|---|
| *Pentacrinus*? *gracilis*, Charlesworth, Lond. Geol. Journ. t. 9. | ............ | Upper Lias, Whitby. |
| *dichotomus*, M'Coy, Ann. Nat. Hist. 1848. | ............ | „ „ |

Undetermined species of *Extracrinus* occur in the Speeton Clay, Coralline Oolite, Cornbrash, Gray Oolite, and Millepore Oolite.

### Asteroidea.

None have occurred to my observation in the Cretaceous or Neocomian strata of Yorkshire, several in the Oolites, and a larger and more varied series in the Middle Lias (Marlstone) at Staithes, and on the coast north of Robin Hood's Bay.

#### *Oolitic Species.*

| | | |
|---|---|---|
| *Astropecten rectus*, M'Coy; Wright, pl. 12. | ............ | Calc. Grit, Filey; Kelloway rock, Newtondale. |
| *claviformis*, Wright, pl. 11. (*A. arenicolus*, Forbes.) | ............ | Kelloway rock, Newtondale. |
| *Orion*, Forbes; Wright, pl. 10 | ............ | „ „ |
| *Scarburgensis*, Wright, pl. 7. f. 2. | ............ | Grey Limestone, White Nab, near Scarborough. |
| *Leckenbyi*, Wright, pl. 7. f. 1 | ............ | Grey Limestone, near White Nab. |
| *Ophiolepis Murravii*, Forbes, sp.; Wright, pls. 14, 17, 19. | ............ | Grey Limestone, White Nab (Mr. Leckenby). |

#### *Liassic Species.*

| | | |
|---|---|---|
| *Astropecten Hastingiæ*, Forbes, Geol. Surv. dec. 1 & 2. f. 1. | ............ | Middle Lias, Staithes. |
| *Aspidura loricata*, Agassiz, Mag. Nat. Hist. 1836. | ............ | „ „ |
| *Ophiolepis Murravii*, Forbes, sp.; Wright, pls. 14, 17, 19. | ............ | „ „ (Dr. Murray). |
| *Ophioderma Milleri*, Phil. .... | [Pl. XIII. fig. 20.] | „ „ |
| *carinata*, Wright, pl. 16. f. 1 | ............ | „ „ |
| *Uraster carinatus*, Wright, pl. 2. f. 1. | ............ | Middle Lias, Boulby. In the Leckenby Collection. |
| *Luidia Murchisoni*, Williamson; Wright, pl. 5. f. 2. | ............ | Middle Lias, Peak. |
| *Plumaster ophiuroides*, Wright, pl. 5. f. 1. | ............ | Middle Lias, Staithes. In the Leckenby Collection. |

### Echinoidea.

Though very probably Echinidal remains exist in the Lias of Yorkshire, I have no distinct record of them.

#### *Cretaceous Species.*

ENDOCYCLICA.

| | | |
|---|---|---|
| *Cidaris Gaultina*, Forbes...... | ............ | Red Chalk, Speeton. |
| *Cyphosoma Königi*, Mant....... | [Pl. I. fig. 14, 1 plate.] | Upper Chalk, Danes' Dike. |
| *Peltastes stellulatus*, Ag.; Wright, pl. 41. f. 1. | ............ | Red Chalk, Speeton (Mr. Wiltshire). |

EXOCYCLICA.

| | | |
|---|---|---|
| *Discoidea cylindrica*, Lam. .... | ............ | Red Chalk, Speeton. |
| *Echinoconus albogalerus*, Klein; Forbes, dec. 3. t. 8; Wright, pls. 49 & 50. | ............ | Upper Chalk, Hessle. |
| *subrotundus*, Mant. t. 17. f. 18–19; Wright, pl. 52. | ............ | Upper Chalk, Danes' Dike. |
| *Ananchytes ovatus*, Leske; Forbes, dec. 4–6. | ............ | " " |
| *hemisphæricus*, Cuv. & Brongn. t. 5. f. 7, 8. | ............ | " " |
| *intumescens*, Ph. ........ | ............ | " " |
| *Micraster cor anguinum*, Leske; Forbes, dec. 3–11; Wright, pl. 62. | ............ | " " |
| *Holaster planus*, Mant......... | [Pl. I. fig. 15.] | " " |
| *hemisphæricus*, Phil. ...... | [Pl. I. fig. 16.] | " " |
| *subglobosus*, Leske ........ | ............ | Red Chalk (upper beds). |

#### *Neocomian Species.*

| | | |
|---|---|---|
| *Cidaris* (species), Phil......... | [Pl. II. figs. 2, 3.] | Speeton. |
| *Toxaster argillaceus*, Phil. .... | [Pl. II. fig. 4.] | " |
| *Pseudodiadema*, sp. .......... | ............ | Upper Clay, Speeton. |

#### *Oolitic Species.*

ENDOCYCLICA.

| | | |
|---|---|---|
| *Cidaris florigemma*, Phil...... | [Pl. III. figs. 12, 13.] | Coralline Oolite, Ayton, Malton. |
| *Smithii*, Wright, pls. 2 & 5 | ............ | Coralline Oolite, Scarborough, Ayton. |

| | | |
|---|---|---|
| *Rhabdocidaris maxima*, Münst.; Wright, pl. 22. | [Pl. IX. fig. 5.] | Grey Oolite, Gristhorpe, Cloughton. |
| *Hemicidaris intermedia*, Flem.; Wright, pl. 4. f. 1. | [Pl. III. fig. 14, spine.] | Coralline Oolite, Malton, Hildenley. |
| *Heterocidaris Wickensis*, Wright. | [Pl. IX. fig. 3.] | Inferior Oolite, Blue Wick. |
| *Pseudodiadema hemisphæricum*, Ag.; Wright, pl. 8. f. 1. (*P. monilipora*, Ph. 1829.) | ............ | Coralline Oolite, Malton. |
| *vagans*, Phil. ............ | [Pl. VII. fig. 1.] | Cornbrash, Grey Oolite, and Infer. Oolite. |
| *Hemipedina corallina*, Wright, pl. 12. f. 1. | ............ | Coralline Oolite, Malton. |
| *Stomechinus germinans*, Phil. .. | [Pl. III. fig. 15.] | Millepore Oolite, Inferior, Whitwell. |
| *Glyptichus hieroglyphicus*, Wright, pl. 13. f. 3. | ............ | Coralline Oolite, Malton. |

EXOCYCLICA.

| | | |
|---|---|---|
| *Holectypus depressus*, Lam. .... | [Pl. VII. fig. 4.] | Cornbrash, Scarborough. |
| *oblongus*, Wright, pl. 18. f. 3 | ............ | Coralline Oolite, Malton; Calc. Grit, Filey. |
| *Pygurus pentagonalis*, Phil. .... | [Pl. IV. fig. 24.] | Coralline Oolite, Malton, Hildenley; Calc. Grit, Scarborough. |
| *Hausmanni*, Koch & Dunker; Wright, pls. 39, 40. | ............ | Coralline Oolite, Settrington. |
| *Phillipsii*, Wright, pl. 39. f. 1 | ............ | Coralline Oolite, Malton. |
| *Pygaster umbrella*, Ag. ........ | [Pl. III. fig. 17.] | Coralline Oolite, Malton. |
| *semisulcatus*, Phil. ........ | ............ | Millepore Oolite, Whitwell. |
| *Collyrites bicordata*, Leske. (*C. ovalis*, Phil. 1829.) | [Pl. IV. fig. 23.] | Coralline Oolite, Oswaldkirk, Malton; Calc. Grit, Castle Howard; Kelloway rock, Hackness. |
| *Clypeus subulatus*, Y.&B.; Wright. (*Clyp. emarginatus*, Phil. 1829.) | [Pl. III. fig. 18.] | ,, ,, Ayton, Scarborough. |
| *Michelinii*, Wright, pl. 30. f. 2 | ............ | Millepore Oolite, Whitwell. |
| *Echinobrissus clunicularis*, Lhwyd. | [Pl. VII. fig. 2.] | Cornbrash, Scarborough. |
| *dimidiatus*, Phil. (probably *scutatus*, Lam.; Wright, pl. 36. f. 2). | [Pl. III. fig. 16.] | Coralline Oolite and Calc. Grit, Malton. Filey, Scarborough. |
| *orbicularis*, Phil. ........ | [Pl. VII. fig. 3.] | Cornbrash, Scarborough. |

## ANNELLIDA.

These belong wholly to the cephalobranchiate division; those which were protected by a shelly covering occur in all the marine strata of the Yorkshire coast, from the Lias to the Chalk. Vermiform tracks and appearances due to naked Annellida are indistinctly observable.

### *Cretaceous Species.*

| | | |
|---|---|---|
| *Serpula solitaria*, Phil. | [Pl. I. fig. 19.] | Red Chalk, Speeton. |
| *Vermicularia umbonata*, Sow. t. 57. f. 7. | ............ | " " |

### *Neocomian Species.*

| | | |
|---|---|---|
| *Serpula articulata*, Sow. t. 599 | ............ | Upper Clay, Speeton. |
| *antiquata*, Sow. t. 598 | ............ | Upper and Middle Clay, Speeton. |
| *filiformis*, Sow. G. J. 2nd ser. 4, t. 16. f. 2. | ............ | " " " |
| *gastrochænoides*, Leym. | ............ | Middle Clay, Speeton. |
| *Vermicularia Sowerbii*, Phil. (*V. Phillipsii*, Röm.) | [Pl. II. fig. 29.] | Upper Clay, Speeton. |

### *Oolitic Species.*

| | | |
|---|---|---|
| *Vermicularia nodus*, Phil. | [Pl. IX. fig. 34.] | M. O. Westow, Whitwell. C. B. Scarborough. |
| *Serpula clava*, Bean, MS. | ............ | C. B. Scarborough. |
| *deplexa*, Bean, MS. | [Pl. IX. fig. 16.] | I. O. Blue Wick. |
| *intestinalis*, Phil. | [Pl. V. fig. 21.] | O. C., C. B., & G. O. Scarborough. |
| *lacerata*, Phil. | [Pl. IV. fig. 35.] | C. B. & G. O. Scarborough. |
| *tetragona*, Sow. t. 599 | ............ | O. C., C. B., & G. O. Scarborough. I. O. Blue Wick. |
| *plicatilis*, Goldf.; L. & M. t. 14. f. 5. | ............ | G. O. White Nab. |
| *sulcata*, Sow. t. 608 | ............ | " " |
| *squamosa*, Phil. | [Pl. IV. fig. 15.] | G. O. Scarborough. |

## CRUSTACEA.

### CIRRIPEDIA.

| | | |
|---|---|---|
| *Pollicipes unguis*, Sow. | ............ | Red Chalk, Speeton. |
| *concinnus*, Morris | [Pl. V. fig. 18.] | O. C. Scarborough. |

### OSTRACODA.

#### *Cretaceous Species.*

| | | |
|---|---|---|
| *Cytherella ovata*, Röm......... | ............ | Red Chalk, Speeton. |

### DECAPODA MACRURA.

#### *Neocomian Species.*

| | | |
|---|---|---|
| *Astacodes falcifer*, Bell, pl. 9. f. 1–5. (*Palinurus uncinatus*, Phil. MS. 1830.) | ............ | In phosphatic nodules, Middle Clay, Speeton. |
| *multicavatus*, Bell, pl. 9. f. 7–8. (*Palinurus multicavatus*, Phil. MS. 1830.) | ............ | " " " |
| *Meyeria ornata*, Phil. 1829 .... | [Pl. III. fig. 2.] | " " " |
| *mucronata*, Phil. ed. ii. 1835 | ............ | " " " |

A larger species than *M. ornata*, with angular and sharply serrated lateral abdominal plates.

| | | |
|---|---|---|
| Undetermined Claw .......... | [Pl. III. fig. 3.] | In Middle Clay, Speeton. |

Referred to *Meyeria mucronata* (Phil. ed. ii. 1835) and afterwards to *Astacodes falcifer* (Bell, 1842), but with doubt in both cases.

From my examination in 1830, of all the known examples of the species first named in this list of Neocomian Decapods, I inferred that it had the large antennæ, small hands, and fimbriated tail of a Palinuroid, and so named it (ed. ii. 1835).

#### *Oolitic Species.*

| | | |
|---|---|---|
| *Eryma Birdii*, Bean, MS. .... | ............ | C. B. Scarborough. I. O. Peak. |
| *Glyphæa leptomana*, Phil. MS... | ............ | O. C. Scarborough, foot of Castle Hill. |
| *rostrata*, Phil. .......... | [Pl. IV. fig. 20.] | C. O. Malton, Scarborough, &c. |
| *scabrosa*, Phil. .......... | ............ | C. O., C. G., O. C., & K. R. Malton, Scarborough, &c. |
| *Stricklandi*, Bean, MS. .. | ............ | K. R. Cayton Bay, in calcareous nodules, lying in clay above the Cornbrash. |
| *Cancer*?, a claw ............ | [Pl. V. fig. 20.] | C. B. Scarborough. |

### POLYZOA.

The very small series now given will undoubtedly be much increased by further search in the Upper Chalk and the Lower Oolites.

#### *Cretaceous Species.*

| | | |
|---|---|---|
| *Ceriopora spongites*, Goldf. t. 10. f. 4. | ............ | Red Chalk, Speeton. |
| *Proboscina dilatata*, D'Orb. t. 632 | ............ | Red Chalk, Speeton. |

### *Oolitic Species.*

| | | |
|---|---|---|
| *Hippothoa Smithii*, Phil. ...... | [Pl. VII. fig. 8.] | C. B. Scarborough, on *Cardium citrinoideum.* |
| *Spiropora* (*Cricopora*) *straminea*, Phil. | [Pl. IX. fig. 1.] | M. O. Ewe Nab, Cloughton Wyke, Cave, Crambe Beck. |
| *Terebellaria ramosissima*, Lamx. t. 82. f. 1, 2. | ............ | C. O. Malton (M'Coy). |

## BRACHIOPODA.

### *Cretaceous Species.*

| | | |
|---|---|---|
| *Terebratula biplicata*, Sow. t. 90. | ............ | Red Chalk, Goodmanham. |
| *carnea*, Sow. t. 15........ | ............ | Chalk, Danes' Dike. |
| *semiglobosa* et *subundata*, Sow. t. 15. | ............ | „ „ Red Chalk, Speeton. |
| *Terebratulina rigida*, Sow.; Dav. pl. 2. fig. 16, 17 (only). | ............ | Red Chalk, Speeton. |
| *striata*, Wahl. (*T. pentagonalis*, Phil.) | [Pl. I. fig. 17.] | Chalk, Danes' Dike. |
| *Magas pumila*, Sow.; Dav. t. 1. f. 1–12. | ............ | Red Chalk, Speeton (Phillips). |
| *Kingena lima*, Dav. .......... | ............ | Lower Chalk, Speeton. |
| *Rhynchonella Mantelliana* .... | ............ | Red Chalk, Speeton. |

*Note.*—The absence of many species usual in the Upper Greensand and the Upper Chalk is remarkable.

### *Neocomian Species.*

| | | |
|---|---|---|
| *Terebratula depressa*, Lam.; Dav. t. 9. f. 1–5. | ............ | Neocomian, Speeton. |
| *hippopus*, Röm. ........ | ............ | „ „ (Judd). |
| *sella*, Sow............... | ............ | Upper and Middle Clay, Speeton (Judd). |
| *obtusa*, Sow.? .......... | [Pl. II. fig. 25.] | Neocomian, Speeton (rare). |
| *Terebratulina Martiniana*, D'Orb.; Dav. pl. 2. fig. 26. | [Pl. II. fig. 28.] | Upper Clay, Speeton, Knapton. |
| *Waldheimia celtica*, Morris; Dav. pl. 9. f. 32–35. | ............ | Middle Clay, Speeton (Judd). |
| *faba*, D'Orb. ............ | ............ | „ „ Knapton. |
| *Rhynchonella lineolata*, Phil. .. | [Pl. II. fig. 27.] | Upper Clay, Knapton, Speeton. |
| *sulcata*, Park; Dav. pl. 10. f. 21, 22. | ............ | Neocomian, Speeton. |
| *Lingula truncata*, Sow......... | ............ | Upper Clay, Speeton (Judd). |

## *Oolitic Species.*

| | | |
|---|---|---|
| *Terebratula Bentleyi*, Davidson . . | . . . . . . . . . . . . | C. B. Scarborough. |
| *bucculenta*, Sow. t. 435 . . . . | . . . . . . . . . . . . | C. O. Malton. |
| *digona*, Sow. t. 96 . . . . . . | . . . . . . . . . . . . | C. B. Scarborough. |
| *globata*, Sow. t. 436 . . . . . . | . . . . . . . . . . . . | G. O. Westow, Whitwell. |
| *insignis*, Schub.; Dav. 3, t. 13. f. 1. | . . . . . . . . . . . . | C. O. Malton. C. G. Castle Howard. |
| *intermedia*, Sow. t. 15 . . . . | . . . . . . . . . . . . | C. B. Scarboro'. G. O. Westow, Whitwell. Cloughton, Swainby. I. O. Blue Wick. |
| *lagenalis*, Schl. . . . . . . . . . . | . . . . . . . . . . . . | C. B. Scarborough. |
| *obovata*, Sow. t. 101 . . . . . . | . . . . . . . . . . . . | " " |
| *ornithocephala*, Sow. t. 101 | [Pl. VI. fig. 7.] | K. R. Hackness. C. B. Scarborough. |
| *trilineata*, Y. & B. t. 8. f. 14 | . . . . . . . . . . . . | C. B. Scarborough, Gristhorpe, Newtondale. I. O. Glaizedale, Cold Moor. |

*Note* the absence of *T. maxillata*, *T. coarctata*, *T. cardium*, the rarity of *T. digona* (triangular variety), all characteristic of the upper part of the Great Oolite and Forest-Marble group of Gloucestershire. *T. coarctata** is supposed to cease about Cirencester, *T. cardium* near Oxford. *T. digona*, of small size, abounds near Northampton, *T. maxillata* being there less plentiful.

| | | |
|---|---|---|
| *Rhynchonella concinna*, Sow. t. 83 | . . . . . . . . . . . . | C. B. Scarborough. |
| *cynocephala*, Rich.; Dav. t. 14. f. 10, 12. | . . . . . . . . . . . . | I. O. Yorkshire (Davidson). |
| *inconstans*, Sow. t. 277 . . . . | [Pl. II. fig. 24.] | K. C. Speeton, Knapton. |
| *obsoleta*, Sow. t. 83 . . . . . . | . . . . . . . . . . . . | I. O. Glaizedale. |
| *socialis*, Phil. (part of *Rh. varians*, Schl.). | [Pl. VI. fig. 8.] | C. G. & K. R. Scarborough, Hackness. C. B. Scarborough. |
| *spinosa*, Smith . . . . . . . . . . | [Pl. IX. fig. 18.] | M. O. Near Cave. I. O. Blue Wick. |
| *Lingula Beanii*, Phil. . . . . . . . . | [Pl. XI. fig. 24.] | I. O. Blue Wick, Castle Howard. |
| *ovalis*, Sow. t. 19. f. 4 . . . . | . . . . . . . . . . . . | K. C. Speeton, on the Scar. |
| *Discina radiata*, Phil. . . . . . . . . | [Pl. IV. fig. 12.] | C. O. Malton. |
| *latissima*, Sow. t. 139 . . . . | . . . . . . . . . . . . | O. C. Scarborough. K. C. Speeton. |
| sp. . . . . . . . . . . . . . . . . . . . | . . . . . . . . . . . . | C. B. Scarborough. |

## *Liassic Species.*

| | | |
|---|---|---|
| *Terebratula punctata*, Sow. t. 15. | . . . . . . . . . . . . | M. L. Kettleness. |
| *resupinata*, Sow. t. 150 . . . . | . . . . . . . . . . . . | M. L. Wilton Castle. |
| *Rhynchonella acuta*, Sow. . . . . . . | [Pl. XIII. fig. 25.] | " " |
| *tetraedra*, Sow. t. 83 . . . . . . | . . . . . . . . . . . . | U. L., M. L. Kettleness, &c. |
| *variabilis*, Schl. { *bidens*, Phil. . . | [Pl. XIII. fig. 24.] | M. L. Staithes, Wilton Castle. |
| *variabilis*, Schl. { *tridentata*, Phil. | [Pl. XIII. fig. 22.] | M. L. Wilton Castle, Staithes, &c. |

* This species has, however, recently been found by Mr. Bentley in the Cornbrash near Peterborough.—R. E.

| | | |
|---|---|---|
| *Spirifera Walcottii*, Sow. t. 377 | ............ | L. L. Rare, Peak. |
| *Discina reflexa*, Sow. t. 506 .... | ............ | U. L. Peak, Whitby. |

## MONOMYARIA.

### OSTREIDÆ.

### *Cretaceous Species.*

| | | |
|---|---|---|
| *Ostrea canaliculata*, D'Orb. .... | ............ | Red Chalk. |
| *Rauliniana*, D'Orb. ...... | ............ | " |
| *vesiculosa*, Sow. t. 369 .... | ............ | " upper part. |

### *Neocomian Species.*

| | | |
|---|---|---|
| *Ostrea frons*, Park. Org. Rem. 3. t. 15. f. 4. | ............ | Upper and Middle Clays, Speeton. |
| *Leymerii*, Desh. Mem. G. S. Fr. 5. t. 13. f. 4. | ............ | Upper Clay, Speeton. |
| *Exogyra parvula*, Leym. ...... | ............ | " " |
| *sinuata*, Sow. .......... | [Pl. II. fig. 23.] | Middle Clay, Speeton. |
| *subsinuata*, Leym......... | ............ | " " |
| *Placunopsis* ................ | ............ | Upper Clay, Speeton. |
| *Plicatula placunea*, Lam.; D'Orb. t. 462. f. 11–18. | ............ | " " |

### *Oolitic Species.*

| | | |
|---|---|---|
| *Ostrea archetypa*, Phil. ........ | [Pl. VI. fig. 9.] | K. R. Scarborough, Wheatcrofts. |
| *deltoidea*, Sow. t. 148 .... | ............ | K. C. Helmsley, Kirkby Moorside, Welton, Ellougton. |
| *duriuscula*, Phil. ........ | [Pl. IV. fig. 1.] | C. O. Malton, Scarborough. |
| *gregaria*, Sow. t. 111 .... | ............ | C. O. Malton. C. G. Scarborough. |
| *Marshii*, Sow. t. 48 ...... | ............ | K. R. Wheatcroft. C. B. Scarborough, Gristhorpe, Newtondale. |
| *Meadii*, Sow. t. 252 ...... | ............ | C. B. Scarborough. |
| *solitaria*, Sow. t. 468 .... | ............ | C. O. Malton. C. B. Scarborough. I. O. Blue Wick. |
| *sulcifera*, Phil. .......... | [Pl. IX. fig. 35.] | M. O. Westow (the young of *O. solitaria*). |
| *undosa*, Bean............ | [Pl. VI. fig. 4.] | K. R. Scarborough. |
| *Gryphæa chamæformis*, Smith, f. 5 | ............ | C. O. & C. G. Hackness. |
| *dilatata*, Sow. t. 149 (=*bullata*). | [Pl. VI. fig. 1. Pl. IV. fig. 36.] | C. O. Malton. K. R. Hackness. C. B. Scarborough. |
| *gigantea*, Sow. t. 391 .... | ............ | G. O. White Nab. |
| *minima*, Phil. ............ | [Pl. IV. fig. 6.] | C. O. Malton. C. B. Scarborough. |
| *nana*, Sow. t. 383........ | ............ | K. C. Speeton Scar. |

| | | |
|---|---|---|
| *Placunopsis inæqualis*, Phil. .... | [Pl. V. fig. 13.] | C. B. & O. C. Scarborough. |
| *semistriata*, Bean, Mag. N. H. 1839, fig. 21. | ............ | C. B. Scarborough. |

### *Liassic Species.*

| | | |
|---|---|---|
| *Gryphæa depressa*, Phil. ...... | [Pl. XIV. fig. 7.] | L. L. Bilsdale. |
| *incurva*, Sow. t. 112 ...... | ............ | L. L. Redcar, Peak. |
| *MacCullochii*, Sow. t. 547 .. | ............ | L. L. Robin Hood's Bay. |
| *Plicatula spinosa*, Sow. ........ | [Pl. XIV. fig. 15.] | L. L. Robin Hood's Bay, Huntcliff. |

## PECTINIDÆ.

### *Cretaceous Species.*

| | | |
|---|---|---|
| *Dianchora striata*, Sow. ...... | ............ | Chalk, Danes' Dike. |
| *Pecten Beaveri*, Sow. t. 158 .... | ............ | Red Chalk, Speeton. |
| *Spondylus gibbosus*, D'Orb. .... | ............ | ,, ,, |

### *Neocomian Species.*

| | | |
|---|---|---|
| *Pecten cinctus*, Sow. (small var.) . | ............ | Upper Clay, Speeton. |
| *cinctus* ?, Sow. (large variety) | ............ | Middle and Lower Clay, Speeton. |
| *elongatus*, Lam. .......... | ............ | Upper Clay, Speeton. |
| *interstriatus*, Leym. ...... | ............ | ,, ,, |
| *orbicularis*, Sow. ........ | ............ | ,, ,, |
| *striato-punctatus*, Röm. .... | ............ | ,, ,, |
| *Lima undata*, Desh. .......... | ............ | ,, ,, |
| *elegans*, Nilss. .......... | ............ | ,, ,, |

### *Oolitic Species.*

| | | |
|---|---|---|
| *Pecten anisopleurus*, Buv.; L. & M. t. 33. f. 5 | ............ | C. B. Scarborough. |
| *arcuatus*, Sow. t. ...... | ............ | M. O. Cloughton. |
| *articulatus*, Schl.; L. & M. t. 33. f. 12. | ............ | C. B., C. G., & C. O. Scarborough. |
| *cingulatus*, Goldf. ........ | [Pl. V. fig. 11.] | C. B. Scarborough. |
| *demissus*, Phil. .......... | [Pl. VI. fig. 5.] | C. O. Malton. K. R. Scarborough. M. O. Cloughton. |
| *fibrosus*, Sow. .......... | [Pl. VI. fig. 3.] | C. O. Malton. K. R. Hackness. |
| *inæquicostatus*, Phil. ...... | [Pl. IV. fig. 10.] | C. O. Malton. K. R. Hackness. C. B. Scarborough. |
| *lens*, Sow. .............. | ............ | C. O. Malton. C. B. Scarborough. G. O. White Nab. I. O. Blue Wick. |
| *subfibrosus*, D'Orb. ...... | ............ | C. O. Malton. C. G. Filey. C. B. Scarborough. |

| | | |
|---|---|---|
| *Pecten vagans*, Sow. t. 543 .... | ............ | C. O. Malton. |
| *vimineus*, Sow. t. 543 .... | ............ | " " |
| *virguliferus*, Phil. ........ | [Pl. XI. fig. 20.] | I. O. Blue Wick. |
| *Hinnites abjectus*, Phil. ........ | [Pl. IX. fig. 37.] | M. O. Whitwell, Westow. |
| *gradus*, Lyc. t. 33. f. 10 .. | ............ | C. B. Scarborough. |
| *Lima argillacea*, Lyc. ........ | [Pl. V. fig. 10.] | O. C. Scarborough. |
| *cardiiformis*, Sow. t. 113 .. | ............ | G. O. White Nab. I. O. Blue Wick. |
| *duplicata*, Sow. t. 559 .... | [Pl. VI. fig. 2.] | K. R. Hackness. C. B. Scarborough. M. O. Cloughton. |
| *elliptica*, Whiteaves ...... | ............ | C. O. |
| *gibbosa*, Sow. ........... | ............ | " |
| *Helvetica*, Oppel.; L. & M. t. 33. f. 8. | ............ | C. B. Scarborough. |
| *interstincta*, Phil. ........ | [Pl. VII. fig. 14.] | M. O. Whitwell. C. B. Scarborough. |
| *læviuscula*, Sow. t. 382.... | ............ | C. O. Malton. |
| *pectiniformis*, Schl. (*L. proboscidea*, Sow. t. 264.) | ............ | C. O. & C. B. Scarborough. I. O. Blue Wick. |
| *punctata*, Sow.; L. & M. t. 15. f. 9. | ............ | G. O. White Nab. |
| *rigida*, Sow. t. 144 ...... | ............ | C. O. Malton. |
| *rigidula*, Phil. .......... | [Pl. VII. fig. 13.] | C. B. Scarborough. |
| *rudis*, Sow. t. 214........ | ............ | C. O. Malton. |

## *Liassic Species.*

| | | |
|---|---|---|
| *Lima gigantea*, Sow. t. 77...... | ............ | L. L. Redcar. |
| *Hermanni*, Voltz ........ | ............ | " " |
| *pectinoides*, Sow. t. 114 .. | [Pl. XII. fig. 13.] | " " |
| *Pecten æquivalvis*, Sow. t. 136 .. | ............ | M. L. Staithes, Grosmont, Egton, &c. |
| *major*, Y. & B. .......... | ............ | M. L. |
| *multicostatus*, Simpson .... | ............ | L. L. |
| *planus*, Simpson ........ | ............ | M. L. |
| *punctatus*, Simpson ...... | ............ | ? |
| *reticularis*, Simpson ...... | ............ | M. L. |
| *sublævis*, Y. & B. ........ | [Pl. XIV. fig. 5.] | M. L. Kettleness, Egton, Grosmont, Bilsdale. |

### AVICULIDÆ.

## *Cretaceous Species.*

| | | |
|---|---|---|
| *Avicula*, sp. ................ | ............ | Red Chalk, Speeton. |
| *Inoceramus Brongniarti*, Sow. t. 441 | ............ | Chalk, Danes' Dike. |
| *Coquandinus*, D'Orb. t. 403. f. 6–8. | ............ | Red Chalk, Speeton. |

| | | |
|---|---|---|
| *Inoceramus cranium*, Phil. (a large smooth vaulted species). | ............ | Chalk, Danes' Dike. |
| *Cuvieri*, Sow. t. 441 ...... | ............ | " " |
| ? *læviusculus*, Bean, MS. .. | ............ | " " |
| *mytiloides*, Sow. t. 442 .... | ............ | " " |

*Note.*—The species here reported require revision, probably reduction.

## *Neocomian Species.*

| | | |
|---|---|---|
| *Avicula*, sp. ................ | ............ | Upper Clay, Speeton. |
| *Gervillia anceps*, Desh.; D'Orb. t. 394. | ............ | " " |
| *Perna Mulleti*, Desh.; D'Orb. t. 400 | ............ | " " |
| *imbricatus*, Bean, MS. .... | ............ | " " |
| *venustulus*, Bean, MS. .... | ............ | " " |
| *Pinna gracilis*, Phil. .......... | [Pl. II. fig. 22.] | " " |

## *Oolitic Species.*

| | | |
|---|---|---|
| *Avicula Braamburiensis*, Phil. .. | [Pl. VI. fig. 6.] | K. R. Hackness. C. B. Scarborough. G. O. Cloughton, White Nab. |
| *echinata*, Sow. t. 243 ...... | ............ | C. B. Scarborough. |
| *elegantissima*, Bean .... | [Pl. IV. fig. 2.] | C. O. Malton. |
| *expansa*, Phil. .......... | [Pl. III. fig. 35.] | C. O. Malton. O. C. Scarborough. K.R. South Cave. |
| *Münsteri*, Goldf. t. 118. f. 2 | ............ | C. B. Scarborough. G. O. White Nab. |
| *ornata*, Goldf. t. 121. f. 7 .. | ............ | C. B. Scarborough. |
| *ovalis*, Phil. ............ | [Pl. III. fig. 36.] | C. O. Malton. C. G. Scarborough. |
| *tonsipluma*, Y. & B. t. 7. f. 15 | ............ | C. O. Malton. |
| *Pteroperna plana*, L. & M. t. 14. f. 4 | ............ | G. O. Scarborough. |
| *Gervillia acuta*, Sow. t. 510 .... | ............ | G. O. White Nab, Brandsby, Cloughton. |
| *aviculoides*, Sow. t. 66 .... | ............ | C. O. Malton. C. G. Filey. C. B. Scarborough. |
| *lata*, Phil. .............. | [Pl. XI. fig. 16.] | M. O. Cloughton. I. O. Blue Wick. |
| *tortuosa*, Phil. (*Gastrochæna*, Phil. 1829.) | [Pl. XI. fig. 36.] | C. B. Scarborough. I. O. Blue Wick. |
| *Perna obliqua*, Lyc. t. 34. f. 22 .. | ............ | C. B. Scarborough. |
| *rugosa*, Goldf. t. 108. (*P. quadrata*, Phil. 1829.) | [Pl. IX. figs. 21, 22.] | G. O. White Nab. |
| *Pinna ampla*, Sow. t. 7 ........ | ............ | I. O. Blue Wick. |
| *cancellata*, Bean; L. & M. t. 13 f. 24. | ............ | G. O. Scarborough. |

| | | |
|---|---|---|
| *Pinna cuneata*, Bean .......... | [Pl. IX. fig. 17.] | C. B. Scarborough. G. O. Cloughton. M. O. Cave. |
| *granulata*, Sow. t. 347 .... | ............ | K. C. Speeton Scar. |
| *lanceolata*, Sow. t. 443 .... | [Pl. IV. fig. 33.] | C. O. & C. G. Malton, Redcliff. C. B. Scarborough. |
| *mitis*, Phil. .............. | [Pl. V. fig. 7.] | O. C. Scarborough. K. R. South Cave. |
| *Trichites* .................... | ............ | C. B. Scarborough. |

### *Liassic Species.*

| | | |
|---|---|---|
| *Avicula cygnipes*, Phil. ........ | [Pl. XIV. fig. 3.] | M. L. Bilsdale, Staithes, Grosmont. |
| *inæquivalvis* ........ | ............ | |
| *novemcostæ*, Brown ........ | [Pl. XIV. fig. 4.] | M. L. Staithes. |
| *Crenatula ventricosa*, Sow. t. 443 | ............ | " " |
| *Inoceramus dubius*, Sow. t. 511 .. | [Pl. XII. fig. 14.] | U. L. Saltwick. |
| *Pinna folium*, Y. & B. ........ | [Pl. XIV. fig. 17.] | L. L. Robin Hood's Bay. |

## DIMYARIA.

### MYTILIDÆ.

### *Oolitic Species.*

| | | |
|---|---|---|
| *Mytilus cuneatus*, Phil. ........ | [Pl. XI. fig. 21.] | M. O. Cloughton. I. O. Glaizedale. |
| *sublævis*, Sow. t. 439. fig. 3 .. | ............ | C. B. Scarborough. |
| *Modiola bipartita*, Sow. t. 210 .. | [Pl. IV. fig. 30.] | K. C. Speeton Scar. C. O. Malton. C. B. Scarborough. |
| *cuneata*, Sow. t. 248 ...... | [Pl. V. fig. 28.] | C. O. Malton. K. R. South Cave. C. B. Scarborough. M. O. Cloughton. |
| *furcata*, Goldf. (*M. aspera*, Phil. 1829.) | [Pl. XI. fig. 9.] | I. O. Blue Wick. |
| *imbricata*, Sow. t. 212 .... | ............ | C. B. Scarborough. M. O. Cloughton. |
| *Leckenbyi*, L. & M. t. 14. f. 8 | ............ | G. O. Scarborough. |
| *Lycetti*, Whiteaves (Ann. Nat. Hist. 1861). | ............ | C. O. Ayton. |
| *pulchra*, Phil. ............ | [Pl. V. fig. 26.] | K. R. Scarborough. |
| *Sowerbyana*, D'Orb. (*M. plicata*, Sow. t. 248.) | ............ | I. O. Blue Wick, Glaizedale, Cold Moor. |
| *ungulata*, Phil.; Y. & B. t. 7. f. 10. | ............ | C. O. Malton. G. O. Cloughton. I. O. Blue Wick. |
| *Lithodomus inclusus*, Phil. ...... | [Pl. III. fig. 20.] | C. O. Malton. |
| sp. .................... | ............ | P. O. Speeton (Judd). |

### *Liassic Species.*

| | | |
|---|---|---|
| *Modiola scalprum*, Sow. t. 248 .. | [Pl. XIV. fig. 2.] | M. L. Staithes. |
| *Hillana*, Sow. t. 212 ...... | ............ | L. L. |

### ARCADÆ.

#### *Neocomian Species.*

| | | |
|---|---|---|
| *Nucula ovata*, Mant. (*N. obtusa*, Judd.) | [Pl. II. fig. 10.] | Upper Clay, Speeton. |
| *subrecurva*, Phil. (*N. scapha*, D'Orb.) | [Pl. II. fig. 11.] | Neocomian, Speeton. |
| *Cucullæa securis*, Leym. ...... | [Pl. II. fig. 16.] | Upper Clay, Speeton (*Judd*). |

#### *Oolitic Species.*

| | | |
|---|---|---|
| *Arca æmula*, Phil. ............ | [Pl. III. fig. 29.] | C. O. Malton. |
| *quadrisulcata*, Sow. t. 473.. | ............ | „ „ |
| *Cucullæa cancellata*, Phil. ...... | [Pl. IX. fig. 24.] | C. B. Scarborough. G. O. Cloughton. I. O. Blue Wick. |
| *clathrata*, Leck.; Lyc. t. 39. f. 4 | ............ | C. B. Scarborough. |
| *concinna*, Phil. .......... | [Pl. V. figs. 9, 31.] | C. O. & O. C. Scarborough. K. R. Cave. C. B. Scarborough. |
| *contracta*, Phil. .......... | [Pl. III. fig. 30.] | C. O. Malton. |
| *corallina*, Damon (*C. oblonga*, Phil. 1829). | [Pl. III. fig. 34.] | C. O. Malton. C. B. Scarborough. |
| *cylindrica*, Phil. .......... | [Pl. IX. fig. 20.] | G. O. White Nab. |
| *elongata*, Sow. t. 447...... | [Pl. III. fig. 33.] | C. O. Malton. M. O. Cave. |
| *imperialis*, Bean ........ | [Pl. IX. fig. 19.] | G. O. Cloughton Wyke. |
| *minima*, Leck. G. J. 1858, pl. 3. f. 5. | ............ | K. R. Scarborough. |
| *pectinata*, Phil. .......... | [Pl. III. fig. 32.] | C. O. & C. G. Malton. |
| *reticulata*, Bean .......... | [Pl. XI. fig. 18.] | I. O. Blue Wick. |
| *Macrodon Hirsonensis*, Lyc. .... | [Pl. XI. fig. 43.] | I. O. Blue Wick (young). |
| *Isoarca Scarburgensis*, Lyc. t. 39. f. 5 | ............ | C. B. Scarborough. |
| *Nucula elliptica*, Phil. ........ | [Pl. V. fig. 6.] | O. C. „ |
| *nucleus*, Desh. .......... | ............ | C. B. „ |
| *nuda*, Y. & B. .......... | [Pl. V. fig. 5.] | O. C. „ |
| *variabilis*, Sow. t. 475 .... | [Pl. IX. fig. 11.] | G. O. Cloughton. I. O. Blue Wick. |
| *Leda anglica*, D'Orb. (*lachryma*, Phil. 1829). | [Pl. XI. fig. 14.] | C. B. Scarborough. G. O. Cloughton. I. O. Blue Wick. |
| sp. .................... | ............ | K. C. Speeton Scar. |

#### *Liassic Species.*

| | | |
|---|---|---|
| *Leda complanata*, Phil. ...... | [Pl. XII. fig. 8.] | Upper Lias, Whitby. |
| *dura*, Simpson .......... | ............ | Middle Lias. |
| *ovum*, Sow. t. 476........ | [Pl. XII. fig. 4.] | Upper part of Upper Lias, Whitby. |
| *rostralis*, Lam. (*L. claviformis*, Sow. t. 476.) | ............ | Upper Lias, Whitby. |

TRIGONIDÆ.

No Neocomian species of *Trigonia* has been seen by myself or any of my friends who have collected at Speeton, except the following, which is recorded by Mr. Judd:—

*Cretaceous Species.*

Group of SCABRÆ.

| | | |
|---|---|---|
| *Trigonia spinosa*?, Park.; Sow. t. 86. | ............ | In the clay cliffs at Speeton. |

*Oolitic Species**.

Group of SCAPHOIDEÆ.

| | | |
|---|---|---|
| *Trigonia recticosta*, Lyc. t. 1. f. 4, 5 | ............ | M. O. Cloughton. I. O. Glaizedale. |

Group of CLAVELLATÆ.

| | | |
|---|---|---|
| *Trigonia clavellata*, Sow. t. 87 .. | ............ | C. O. & C. G. Malton, Filey. |
| *complanata*, Lyc. t. 7. f. 5 .. | ............ | K. R. Scarborough. |
| *corallina*, D'Orb.; Lyc. t. 3. f. 7, 11. t. 8. f. 3. | ............ | C. O. Pickering. |
| *perlata*, Ag.; Lyc. t. 3. f. 1–3 | ............ | C. G. Pickering. |
| *Rupellensis*, D'Orb.; Lyc. t. 8. f. 4. | ............ | K. R. Red Cliff. |
| *Scarburgensis*, Lyc. t. 4. f. 1–4 | ............ | C. B. Scarborough, Cayton Bay. |
| *signata*, Ag.; Lyc. t. 2. f. 1–3 | ............ | G. O. Cloughton. |
| *spinulosa*, Y. & B. (*T. striata*, Phil. 1829); Lyc. t. 3. f. 4–6. | [Pl. XI. fig. 38.] | I. O. Blue Wick. |
| *triquetra*, Seeb.; Lyc. t. 6. f. 1–2. | ............ | C. G. Filey. |
| *Williamsoni*, Lyc. t. 16. f. 8 | ............ | K. R. Red Cliff. |

Group of COSTATÆ.

| | | |
|---|---|---|
| *Trigonia Cassiope*, D'Orb. .... | ............ | C. B. Scarborough. |
| *denticulata*, Ag. ........ | ............ | K. R. Red Cliff. G. O. Cloughton. I. O. Blue Wick. |
| *elongata*, Sow. (var. *angustata*, Lyc.). | ............ | C. B. Red Cliff. |
| *Meriani*, Ag. ............ | ............ | C. O. Malton, Pickering. |
| *tenuicosta*, Lyc. .......... | ............ | G. O. Cloughton. |

Group of UNDULATÆ.

| | | |
|---|---|---|
| *Trigonia conjungens*, Phil.; Lyc. t. 10. f. 5, 7, 8. | ............ | M. O. Cloughton. |

* This list is drawn up in accordance with the Monograph of Dr. Lycett, Pal. Soc. Mem.

| | | |
|---|---|---|
| *Trigonia geographica*, Ag.; Lyc. t. 10. f. 6. | ............ | C. O. Malton. |
| *paucicosta*, Lyc. t. 11. f. 8–9. t. 16. f. 7. | ............ | K. R. Red Cliff. |
| *Sharpiana*, Lyc. t. 15. f. 11. t. 16. f. 4–6. | ............ | I. O. Blue Wick. |
| *v. costata*, Lyc. t. 15. f. 1–4.. | ............ | " " |

## *Liassic Species.*

### Group of UNDULATÆ.

| | | |
|---|---|---|
| *Trigonia Leckenbyi*, Lyc. t. 16. f. 1–2. | ............ | Midford Sands, Blue Wick. |
| *literata*, Y. & B. .......... | [Pl. XII. fig. 10.] | Upper Lias, Robin Hood's Bay. |

### Group of GLABRÆ.

| | | |
|---|---|---|
| *Trigonia Lingonensis*, Dumortier; Lyc. t. 22. f. 1–4. | [Pl. XIV. fig. 11.] | M. L. Eston Nab. |

### UNIONIDÆ.

| | | |
|---|---|---|
| *Unio distortus*, Bean, Mag. N. Hist. vol. ix. p. 376. | ............ | Middle Shale, Gristhorpe. |
| *insperatus*, Phil. MS., a small oval species. | ............ | Upper Shale, White Nab. Ironstone, in Lower Shale, Haiburn Wyke. |

### CARDIIDÆ.

## *Oolitic Species.*

| | | |
|---|---|---|
| *Cardium citrinoïdeum*, Phil..... | [Pl. VII. fig. 7.] | C. B. Scarborough. |
| *cognatum*, Phil. .......... | [Pl. IX. fig. 14.] | K. R. & C. B. Scarborough. G. O. Cloughton Wyke. |
| *Crawfordii*, Leck. G. J. vol. xiv. pl. 3. f. 9. | ............ | K. R. Scarborough. |
| *gibberulum*, Phil. ........ | [Pl. XI. fig. 8.] | I. O. Blue Wick. |
| *globosum*, Bean, Mag. N. H. 1839, f. 19. | ............ | C. B. Scarborough. |
| *incertum*, Phil. .......... | [Pl. XI. fig. 5.] | I. O. Blue Wick. |
| *latum*, Bean, MS. ........ | ............ | C. B. Scarborough. |
| *lobatum*, Phil. .......... | [Pl. IV. fig. 3.] | C. O. Malton. C. B. Scarborough. |
| *semiglabrum*, Phil. ...... | [Pl. IX. fig. 15.] | Cloughton Wyke. |
| *striatulum*, Sow. ........ | [Pl. XI. fig. 7.] | M. O. Cloughton. I. O. Blue Wick. |
| *fallax*, Phil. (*C. dissimile*, Phil. 1829.) | [Pl. V. fig. 27.] | O. C. Scarborough. |

### *Liassic Species.*

| | | |
|---|---|---|
| *Cardium multicostatum*, Phil. .. | [Pl. XIII. fig. 21.] | Lower Lias, Bilsdale, Redcar. |
| *truncatum*, Sow. ........ | [Pl. XIII. fig. 14.] | M. L. Staithes, Kettleness. |

### LUCINIDÆ.

### *Neocomian Species.*

| | | |
|---|---|---|
| *Lucina sculpta*, Phil. ........ | [Pl. II. fig. 15.] | Middle Clay, Speeton. |
| *Corbis*, sp.................. | ............ | Upper Clay, Speeton. |

### *Oolitic Species.*

| | | |
|---|---|---|
| *Lucina ampliata*, Phil......... | [Pl. III. fig. 24.] | C. O. Malton. |
| *Beanii*, Lyc. t. 38. f. 3..... | ............ | C. B. Scarborough. |
| *Bellona*, D'Orb.; L.&M. t. 6. f. 15, 18. | ............ | " " |
| *crassa*, Sow. t. 557 ...... | ............ | " " |
| *despecta*, Phil. .......... | [Pl. IX. fig. 8.] | G. O. Cloughton. I. O. Blue Wick. C. B. Scarborough. |
| *lirata*, Phil. ............ | [Pl. VI. fig. 11.] | K. R. Scarborough. |
| *Portlandica*, Sow. G. T. ii. 4. t. 22. f. 12. | ............ | Portlandian bed, Speeton. |
| *Corbicella Buvignieri*, Desh..... | ............ | C. O. |
| *decussata*, Bean .......... | ............ | " |
| *lævis*, Sow. t. 580 ........ | [Pl. V. fig. 32.] | C. O. Malton. K. R. South Cave. |
| *ovalis*, Phil. ............ | [Pl. V. fig. 29.] | K. R. & C. B. Scarborough. |
| *subæquilateralis*, Lyc. t. 35. f. 12. | ............ | C. B. Scarborough. |
| *uniformis*, Bean ........ | ............ | C. O. |
| *Tancredia axiniformis*, Phil. .. | [Pl. XI. fig. 13.] | I. O. Blue Wick. |
| *curtansata*, Phil. ........ | [Pl. III. fig. 27.] | C. O. Malton. K. R. Red Cliff. |
| *Unicardium depressum*, Phil. .. | [Pl. IX. fig. 16.] | C. B. Scarborough. G. O. Cloughton. |
| *gibbosum*, L. & M. t. 14. f. 11 | ............ | G. O. Scarborough. M. O. Cloughton. |
| *sulcatum*, Leck. G. J. vol. xiv. pl. 3. f. 11. | ............ | K. R. & C. B. Scarborough. |

### *Liassic Species.*

| | | |
|---|---|---|
| *Corbis uniformis*, Phil......... | [Pl. XII. fig. 3.] | U. L. Whitby. |
| *Unicardium cardioïdeum*, Phil... | [Pl. XIV. fig. 12.] | L. L. Robin Hood's Bay. |

### CYPRINIDÆ.

### *Neocomian Species.*

| | | |
|---|---|---|
| *Astarte lævis*, Phil. .......... | [Pl. II. figs. 18, 19.] | Neocomian, Speeton. |
| *laticosta*, Desh. .......... | ............ | " " |
| *Isocardia angulata*, Phil. ...... | [Pl. II. figs. 20, 21.] | " " |

## *Oolitic Species.*

| | | |
|---|---|---|
| *Astarte aliena*, Phil. .......... | [Pl. III. fig. 22.] | C. O. Malton. |
| *Aytonensis*, Bean; Lyc. t. 40. f. 13. | ............ | C. O. Ayton. |
| *carinata*, Phil. .......... | [Pl. V. fig. 3.] | K. R. South Cave. |
| *elegans*, Sow. ............ | [Pl. XI. fig. 41.] | C. B. Scarborough. I. O. Blue Wick. |
| *extensa*, Phil. .......... | [Pl. III. fig. 21.] | C. O. Malton. |
| *Leckenbyi*, Wright; Lyc. t. 42. f. 3. | ............ | C. B. Scarborough. |
| *minima*, Phil. .......... | [Pl. IX. fig. 23.] | G. O. Brandsby. M. O. Cloughton. I. O. Blue Wick, Rosebury. |
| *ovata*, Smith ............ | [Pl. III. fig. 25.] | C. O. Malton. |
| *politula*, Bean; Lyc. t. 35. f. 16. | ............ | C. B. Scarborough. |
| *recondita*, Phil. .......... | [Pl. IX. fig. 13.] | G. O. White Nab. M. O. Cloughton. |
| *robusta*, Lyc. t. 35. f. 6 .... | ............ | C. B. Scarborough. |
| *rhomboidalis*, Phil. ...... | [Pl. III. fig. 28.] | C. O. Malton. |
| *ungulata*, Lyc. (*A. lurida*, Phil. 1829.) | [Pl. V. fig. 2.] | O. C., K. R., & C. B. Scarborough. |
| *Isocardia clarissima*, Leck. G. J. vol. xiv. pl. 3. f. 10. | ............ | K. R. Scarborough. |
| *cordata*, Buck. Geol. Chelt. t. 7. f. 1. | ............ | M. O. Cloughton. |
| *minima*, Sow. t. 295 ...... | [Pl. VII. fig. 6.] | C. B. Scarborough. |
| *nitida*, Phil. ............ | [Pl. IX. fig. 10.] | „ „ G. O. Cloughton. |
| *tenera*, Sow. (*I. tumida*, Phil. 1829.) | [Pl. IV. fig. 25.] | C. G. Gristhorpe, Cayton. C. B. Scarborough. |
| *Cyprina corallina*, D'Orb. .... | ............ | C. O. |
| *depressiuscula* ?, L. & M. .. | [Pl. V. fig. 30.] | K. R. South Cave, Newbald. |
| *Cypricardia rostrata*, Sow.; L. & M. t. 7. f. 9. | ............ | I. O. Blue Wick. |
| *cordiformis*, Desh. (*Cardium acutangulum*, Phil. 1829.) | [Pl. XI. fig. 6.] | G. O. Brandsby. I. O. Blue Wick. |
| *Leckenbyi*, Lyc. t. 37. f. 9 .. | ............ | C. B. Scarborough. |
| *Opis Leckenbyi*, Lyc. .......... | ............ | „ „ |
| *Phillipsii*, Morris. (*O. similis*, Phil. 1829.) | [Pl. III. fig. 23.] | C. O. Malton. |
| *similis*, Sow. ............ | [Pl. XI. fig. 39.] | I. O. Blue Wick. |
| *Myoconcha texta*, Buv. ........ | ............ | C. O. |

## *Liassic Species.*

| | | |
|---|---|---|
| *Isocardia petricosta*, Simpson .. | ............ | M. L. |

| | | |
|---|---|---|
| *Hippopodium ponderosum*, Sow. t. 250. | ............ | L. L. Robin Hood's Bay. |
| *Cardinia concinna*, Sow. t. 223.. | ............ | U. L. & M. L. Whitby. |
| *crassiuscula*, Stutchbury, Ann. N. H. 1842. | [Pl. XIII. fig. 16.] | M. L. Robin Hood's Bay. L. L. Pocklington. |
| *lanceolata*, Stutchbury, Ann. N. H. 1842. | ............ | L. L. Robin Hood's Bay. |
| *Listeri*, Sow. t. 154 ...... | ............ | L. L. Redcar. |
| *ovalis*, Stutchbury ...... | ............ | L. L. |
| *Astarte Oppelii* .............. | ............ | ,, |
| *Cypricardia cucullata*, Goldf. .. | ............ | M. L. |

VENERIDÆ.

*Oolitic Species.*

| | | |
|---|---|---|
| *Cytherea? dolabra*, Phil. ...... | [Pl. IX. fig. 12.] | G. O. Cloughton. |

MACTRIDÆ.

| | | |
|---|---|---|
| *Mactra veterum*, Phil. MS. .... | ............ | I. O. Glaizedale. |
| *Sowerbya triangularis*, Phil. .. | [Pl. III. fig. 31.] | C. B. Scarborough. |

TELLINIDÆ.

| | | |
|---|---|---|
| *Quenstedtia lævigata*, Phil. .... | [Pl. IV. fig. 5.] | C. O. Malton. C. B. Scarborough. G. O. Cloughton. I. O. Blue Wick. |
| *oblita*, Phil. ............ | [Pl. XI. fig. 15.] | C. B. Scarborough. I. O. Blue Wick. |
| *Sanguinolaria vetusta*, Phil..... | [Pl. XIV. fig. 1.] | L. L. Robin Hood's Bay. |

MYACIDÆ.

*Neocomian Species.*

| | | |
|---|---|---|
| *Mya phaseolina*, Phil. ........ | [Pl. II. fig. 13.] | Upper Clay, Speeton. |
| *Corbula punctum*, Phil. ...... | [Pl. II. fig. 6.] | Neocomian, Speeton. |
| *Thetis Sowerbyi*, Röm. ........ | ............ | Upper Clay, Speeton. |
| *Panopæa plicata*, Sow. t. 419 .. | ............ | ,, ,, |
| *neocomiensis*, Leym. G. S. Tr. 5. t. 3. f. 4. | ............ | Neocomian, Speeton. |

*Oolitic Species.*

| | | |
|---|---|---|
| *Panopæa Deshaysii*, Buv. ...... | ............ | C. O. |

ANATINIDÆ.

*Neocomian Species.*

| | | |
|---|---|---|
| *Thracia Phillipsii*, Röm. ...... | [Pl. II. fig. 8.] | Neocomian, Speeton. |

| | | |
|---|---|---|
| *Pholadomya decussata*, Phil. 1829 | [Pl. II. fig. 9.] | Neocomian, Speeton. |
| *Martini*, Forbes, G. J. i. t. 2. f. 5 | ............ | „ „ |

## *Oolitic Species.*

| | | |
|---|---|---|
| *Anatina versicostata*, Buv.; Leck. G. J. vol. xiv. pl. 3. f. 6. | ............ | K. R. Scarborough. |
| *undulata*, Sow. .......... | [Pl. V. fig. 1.] | C. B. Scarborough. |
| *Thracia depressa*, Sow. t. 418 .. | ............ | K. C. Speeton Scar. |
| *incerta*, Thurm. .......... | ............ | C. G. |
| *Pholadomya acuticosta*, Sow. t. 546 | ............ | G. O. White Nab. |
| *angustata*, Sow. t. 327 .... | ............ | C. G. & C. B. Scarborough. |
| *cingulata*, Ag. .......... | ............ | C. G. |
| *deltoidea*, Sow. t. 197 .... | ............ | C. G. Malton. |
| *gracilis*, Ag. ............ | ............ | C. G. |
| *Heraultii*, Ag.; L.&M. t. 12. f. 1 | ............ | M. O. Cloughton. |
| *nana*, Phil. ............ | [Pl. IX. fig. 7.] | C. B. Scarborough. G. O. White Nab. |
| *obsoleta*, Phil. ............ | [Pl. V. fig. 24.] | O. C. & K. R. Scarborough. |
| *ovalis*, Sow. t. 226 ........ | ............ | C. B. Scarborough. G. O. White Nab. |
| *ovulum*, Ag.; L.&M. t. 13. f. 12 | ............ | C. O. & C. B. Scarborough. G. O. White Nab. |
| *paucicostata*, Ag. ........ | ............ | C. O. |
| *Phillipsii*, Morr. (*P. Murchisoni*, Phil. 1829.) | [Pl. VII. fig. 9.] | C. B. Gristhorpe, Scarborough. |
| *producta*, Sow. t. 197 .... | ............ | |
| *Sæmanni*, L. & M. t. 11. f. 1 | ............ | G. O. & M. O. Cloughton. G. O. White Nab. |
| *simplex*, Phil. .......... | [Pl. IV. fig. 31.] | C. G. Gristhorpe. |
| *Homomya crassiuscula*, Lyc. t. 43. f. 5 | ............ | C. B. Scarborough. |
| *Myacites æquatus*, Phil. ........ | [Pl. XI. fig. 12.] | G. O. White Nab. I. O. Blue Wick. |
| *Beanii*, L. & M. t. 15. f. 11 | ............ | G. O. Scarborough. |
| *calceiformis*, Phil. ........ | [Pl. XI. fig. 3*.] | K. R. Scarborough, Scalby. C. B. Scarborough. |
| *compressiusculus*, Lyc. .... | ............ | M. O. Cloughton. |
| *decurtatus*, Phil. ........ | [Pl. VII. fig. 11.] | C. B. Scarborough. G. O. White Nab. |
| *decussatus*, Bean, MS. .... | ............ | C. B. Scarborough, |
| *dilatus*, Phil. ............ | [Pl. XI. fig. 4.] | I. O. Glaizedale. |
| *modicus*, Bean; Lyc. t. 43. f. 1 | ............ | C. B. Gristhorpe. |
| *recurvus*, Phil. .......... | [Pl. V. fig. 25.] | C. O. & K. R. Hackness. C. B. Scarborough. |

* This figure is said by Dr. Lycett to have been taken from a specimen belonging to the Cornbrash.

| | | |
|---|---|---|
| *Myacites Scarburgensis*, L. & M. (*M. Phillipsii*, Morris.) | [Pl. IX. fig. 6.] | G. O. Scarborough. |
| *securiformis*, Phil. ........ | [Pl. VII. fig. 10.] | C. B. Scarborough. G. O. White Nab. |
| *sinister*, Ag.; Lyc. t. 35. f. 17 | ............ | C. B. Scarborough. |
| *Goniomya literata*, Sow. t. 224. f. 1 | [Pl. VII. fig. 5.] | C. O. Malton. M. O. Cloughton. |
| *sulcata*, Ag. ............ | ............ | C. B. Scarborough. |
| *v-scripta*, Sow. t. 224. f. 2–5 | ............ | C. B. Scarborough. G. O. Cloughton. |
| *Ceromya Bajociana*, D'Orb. .... | [Pl. XI. fig. 40.] | I. O. Blue Wick. |
| *excentrica*?, Ag. .......... | ............ | K. C. Speeton Scar (Judd). |
| *Studeri*, Ag. ............ | ............ | C. G. |
| *Gresslya abducta*, Phil. ........ | [Pl. XI. fig. 42.] | C. B. Scarborough. M. O. Cloughton. I. O. Blue Wick. |
| *peregrina*, Phil. .......... | [Pl. VII. fig. 12.] | C. B. Scarborough. G. O. White Nab. |
| *Solemya Woodwardiana*, Leck. G. J. vol. xiv. pl. 3. f. 7. | ............ | K. R. Scarborough. |

### *Liassic Species.*

| | | |
|---|---|---|
| *Pholadomya ambigua*, Sow. .... | ............ | L. L. Hunt Cliff. |
| *gallina*, Simpson ........ | ............ | U. L. |
| *obliquata*, Phil. .......... | [Pl. XIII. fig. 15.] | M. L. Staithes, &c. |
| *rostellata*, Simpson ...... | ............ | L. L. |
| *Myacites donaciformis*, Phil. .... | [Pl. XII. fig. 5.] | U. L. Whitby. |
| *elegans*, Phil. ............ | [Pl. XII. fig. 9.] | U. L. In nodules (rare). |
| *grandævus*, Phil. ........ | ............ | L. L. Redcar. |
| *liassinus*, Quenst. ........ | ............ | M. L. |
| *rotundatus*, Phil. ........ | [Pl. XII. fig. 6.] | U. L. Whitby. |
| *Goniomya literata* ............ | ............ | M. L. |
| *Gresslya granata*, Simpson .... | ............ | U. L. |

## GASTROCHÆNIDÆ.

### *Oolitic Species.*

| | | |
|---|---|---|
| *Gastrochæna Moreana*, Buv. .... | ............ | C. O |

## PHOLADIDÆ.

### *Neocomian Species.*

| | | |
|---|---|---|
| *Pholas constricta*, Phil. ........ | [Pl. II. fig. 17.] | Neocomian, Speeton. |
| *Teredo*, sp. .................. | ............ | " " (Judd). |

### *Oolitic Species.*

| | | |
|---|---|---|
| *Pholas costellata*, L. & M. t. 13. f. 18 | ............ | C. B. Scarborough. M. O. Cloughton. |
| *pulchralis*, Bean; L. & M. t. 13. f. 17. | ............ | G. O. White Nab. |
| *recondita*, Phil. .......... | [Pl. III. fig. 19.] | G. O. Malton. |

## HOLOSTOMATA.

### NATICIDÆ.

#### *Oolitic Species.*

| | | |
|---|---|---|
| *Natica arguta*, Phil. .......... | ............ | C. O. Malton. |
| *adducta*, Phil. .......... | [Pl. IX. fig. 30.] | M. O. Cloughton. I. O. Blue Wick. |
| *cincta*, Phil. ............ | [Pl. IV. fig. 9.] | C. O. Malton. In Leeds Museum. |
| *clymenia*, D'Orb. ........ | ............ | C. O. |
| *tumidula*, Phil. .......... | [Pl. XI. fig. 25.] | I. O. Blue Wick. |
| *punctura*, Lyc. & Mor. pl. 15. f. 18. | ............ | K. R. & C. B. Scarborough. I. O. Blue Wick. |
| *insignis*, Lyc. t. 45. f. 21 .. | ............ | C. B. Scarborough. |

#### *Liassic Species.*

| | | |
|---|---|---|
| *Natica Pelops*, D'Orb. ........ | ............ | U. L. |

### PYRAMIDELLIDÆ.

#### *Oolitic Species.*

| | | |
|---|---|---|
| *Chemnitzia Heddingtonensis*, Sow. t. 39. | ............ | C. O. Malton |
| *melanioides*, Phil. ........ | [Pl. IV. fig. 13.] | C. O. Pickering. |
| *lineata*, Sow. t. 218 ...... | ............ | I. O. Blue Wick. |
| *lineata*, Leck. G. J. vol. xv. pl. 3. f. 14. | ............ | K. R. Scarborough. |
| *Scarburgensis*, L. & M. t. 15 | ............ | G. O. Scarborough Coast. |
| *vetusta*, Phil. ............ | [Pl. IX. fig. 27.] | I. O. Blue Wick. M. O. Cloughton. |
| *vittata*, Phil. ............ | [Pl. VII. fig. 15.] | C. B. Scarborough, Gristhorpe. M. O. Cloughton. |
| *Eulima lævigata*, L. & M. t. 15. f. 4 | ............ | C. B. Scarborough. |

### CERITHIADÆ.

#### *Neocomian Species.*

| | | |
|---|---|---|
| *Cerithium aculeatum*, Bean, MS. . | ............ | Lower Clay, Speeton. |
| *Clementinum*, D'Orb. ...... | ............ | Upper Clay, Speeton. |
| *Phillipsii*, Leym. ........ | [Pl. II. fig. 38.] | Middle Clay, Speeton. |

#### *Oolitic Species.*

| | | |
|---|---|---|
| *Cerithium abbreviatum*, Leck. G. J. vol. xiv. pl. 3. f. 12. | ............ | K. R. Scarborough. |
| *Beanii*, L. & M. t. 15. f. 5. . | ............ | G. O. Scarborough. |
| *Culleni*, Leck. G. J. vol. xv. pl. 3. f. 13. | ............ | K. R. Scarborough. |
| *limæforme* .............. | ............ | C. O. Pickering. |

| | | |
|---|---|---|
| *Cerithium muricatum*, Sow. .... | [Pl. IV. fig. 8.] | C. O. & C. G. Malton, Seamer. C. B. Scarborough. |
| *quadrivittatum*, Phil. ...... | [Pl. XI. fig. 23.] | I. O. Blue Wick. |
| *gemmatum*, L. & M. t. 15. f. 6 | ............ | M. O. Cloughton. C. B. Scarborough. |
| *Scarburgense*, L. & M. t. 15. f. 8 | ............ | G. O. White Nab. |
| *Nerinæa cingenda*, Phil. ...... | [Pl. XI. figs. 28, 29.] | G. O. Cloughton, Brandsby. C. B. Scarborough. |
| *cingenda*, Sow. .......... | ............ | I. O. Blue Wick. |
| *Römeri*, Goldf. t. 186 .... | ............ | C. O. Scarborough. |
| *visurgis*, Röm. .......... | ............ | C. O. |
| *granulata*, Phil. .......... | [Pl. VII. fig. 16.] | C. B. Scarborough. |
| *Alaria bispinosa*, Phil. ........ | [Pl. IV. fig. 32.] | C. G. & K. R. Scarborough. |
| *Myurus*, Desl. .......... | [Pl. VI. fig. 13.] | C. B. Scarborough. |
| *Phillipsii*, D'Orb. ........ | [Pl. IX. fig. 28.] | G. O. Scarborough. M. O. Cloughton. I. O. Blue Wick. |
| *trifida*, Phil. ............ | [Pl. V. fig. 14.] | O. C. Scarborough. |

### *Liassic Species.*

| | | |
|---|---|---|
| *Cerithium defossum* .......... | ............ | M. L. |

TURRITELLIDÆ? OR CERITHIADÆ?

### *Neocomian Species.*

| | | |
|---|---|---|
| *Turritella? lævigata*, Leym. .... | ............ | Upper Clay, Speeton. |

LITTORINIDÆ.

### *Neocomian Species.*

| | | |
|---|---|---|
| *Solarium tabulatum*, Phil. ...... | [Pl. II. fig. 36.] | Upper Clay, Speeton. |

### *Oolitic Species.*

| | | |
|---|---|---|
| *Amberleya armigera*, L. & M. t. 31. f. 6. | ............ | C. B. Scarborough. |
| *Littorina funiculata*, Phil. ...... | [Pl. IV. fig. 11.] | C. O. Malton. |
| *muricata*, Sow. .......... | [Pl. IV. fig. 14.] | " " |
| *unicarinata*, Bean, MS. .... | ............ | I. O. Blue Wick. |

NERITIDÆ.

### *Oolitic Species.*

| | | |
|---|---|---|
| *Neritopsis Archiaci*, D'Orb. .... | ............ | C. B. Scarborough. |
| *Guerrii*, E. Desl. ........ | ............ | C. O. |
| *pseudocostata*, D'Orb. .... | [Pl. XI. fig. 32.] | M. O. Cloughton. I. O. Blue Wick. |
| *Nerita costata*, Phil. 1829 ...... | ............ | |
| *lævigata*, Sow. .......... | ............ | C. O. |
| *bullata* ................ | ............ | " |

### TURBINIDÆ.

#### *Neocomian Species.*

| | | |
|---|---|---|
| ***Trochus pulcherrimus***, Phil. .... | [Pl. II. fig. 35.] | Upper Clay, Speeton. |
| ***Delphinula inconspicua***, Phil. .. | [Pl. II. fig. 32.] | " " |

#### *Oolitic Species.*

| | | |
|---|---|---|
| ***Turbo elaboratus***, Bean, L. & M. t. 9. f. 27; t. 15. f. 2. | ............ | C. B. Scarborough. M. O. Cloughton. |
| ***Phillipsii***, L. & M. t. 15. f. 12 | ............ | C.B.&G. O. Scarboro'. M. O. Cloughton. |
| ***sulcostomus***, Phil. ........ | [Pl. VI. fig. 10.] | K. R. Hackness, South Cave. |
| ***Phasianella cincta***, Phil. ...... | [Pl. IX. fig. 29.] | G. O. Cloughton, Brandsby. |
| ***latiuscula***, L. & M. t. 15. f. 16 | ............ | G. O. White Nab. |
| ***striata***, Sow. t. 47........ | ............ | C. O. Malton. |
| A short obtuse species analogous to *P. striata*. | ............ | G. O. Scarborough. |
| ***Trochus angulatus***, Goldf. ...... | ............ | C. B. Scarborough. |
| ***bisertus***, Phil. .......... | [Pl. XI. fig. 27.] | I. O. Blue Wick. |
| ***Leckenbyi***, L. & M. t. 15. f. 21 | ............ | G. O. Scarborough. |
| ***monilitectus***, Bean ........ | [Pl. IX. fig. 33.] | C. B. Scarborough. M. O. Cloughton. |
| ***pyramidatus***, Phil. ...... | [Pl. XI. fig. 22.] | I. O. Blue Wick. |
| ***strigosus***, Lyc. .......... | ............ | C. B. Gristhorpe. |

### HALIOTIDÆ.

#### *Neocomian Species.*

| | | |
|---|---|---|
| ***Pleurotomaria provincialis***, D'Orb. | ............ | Lower Clay, Speeton. |

#### *Oolitic Species.*

| | | |
|---|---|---|
| ***Pleurotomaria bicarinata***, Sow. t. 221. | ............ | C. G. Gristhorpe. |
| ***granulata***, Sow. t. 220 .... | ............ | C. O. & C. G. Malton. C. B. Scarborough. |
| ***arenosa***, Leck. G. J. vol. xv. pl. 3. f. 1 | ............ | K. R. Scarborough. |
| ***guttata***, Phil. ............ | [Pl. VI. fig. 14.] | K. R. Scarborough. |
| ***depressa***, Phil. .......... | [Pl. VI. fig. 12.] | K. R. Hackness, Scarborough. |
| ***cingulata***, Phil. .......... | [Pl. IV. fig. 28.] | C. G. Scarborough. |
| ***reticulata***, Sow. .......... | ............ | C. O. |
| ***striata***, Leck. G. J. vol. xv. pl. 3. f. 2. | ............ | K. R. Scarborough. |
| ***Trochotoma calyx***, Phil. ........ | [Pl. XI. fig. 30.] | I. O. Blue Wick. |
| ***tornata***, Phil. ............ | [Pl. IV. fig. 16.] | C. O. Scarborough. |

#### *Liassic Species.*

| | | |
|---|---|---|
| ***Cryptænia expansa***, Sow. ...... | ............ | M. L. |
| ***Pleurotomaria*** (***Turbo***) ***undulata***, Phill. | [Pl. XIII. fig. 18.] | M. L. Staithes. |

### DENTALIIDÆ.

#### *Neocomian Species.*

| | | |
|---|---|---|
| *Dentalium ellipticum?*, .... | ............ | Upper Clay, Speeton. |
| *lævigatum*, Bean, MS. .... | ............ | Lower Clay, Speeton. |

#### *Oolitic Species.*

| | | |
|---|---|---|
| *Dentalium entaloideum*, Desh. .. | [Pl. IV. fig. 37.] | C.O. & C.G. Cayton. C.B. Scarborough. |

#### *Liassic Species.*

| | | |
|---|---|---|
| *Dentalium giganteum*, Phil. .... | [Pl. XIV. fig. 8.] | M. L. Robin Hood's Bay, Staithes. |

### PATELLIDÆ.

| | | |
|---|---|---|
| *Patella? graphica*, Leck. G. J. vol. xv. pl. 3. f. 3. | ............ | K. R. Scarborough. |

### FISSURELLIDÆ.

#### *Neocomian Species.*

| | | |
|---|---|---|
| *Emarginula neocomiensis*, D'Orb. | ............ | Upper Clay, Speeton. |

### TORNATELLIDÆ.

| | | |
|---|---|---|
| *Avellana obsoleta*, Phil......... | [Pl. II. fig. 40.] | Upper Clay, Speeton. |

#### *Oolitic Species.*

| | | |
|---|---|---|
| *Actæon humeralis*, Phil. ...... | [Pl. XI. fig. 34.] | I. O. Blue Wick. |
| *pullus*, L. & M. t. 15. f. 11.. | ............ | G. O. Scarborough. |
| *retusus*, Phil. ............ | [Pl. IV. fig. 27.] | C. O. Scarborough. |
| *Sedgvickii*, Phil. ........ | [Pl. XI. fig. 33.] | I. O. Blue Wick. M. O. Cloughton. C. B. Scarborough. |
| *Actæonina gigantea*, Deal.; L. & M. t. 15. f. 13. | ............ | G. O. White Nab. |
| *glabra*, Phil. ............ | [Pl. IX. fig. 31.] | G. O. Scarborough. M. O. Cloughton. |
| *Scarburgensis*, Lyc. ...... | ............ | C. B. Scarborough. |
| *tumidula*, L. & M. t. 15. f. 14 | ............ | G. O. Scarborough. |

### BULLIDÆ.

| | | |
|---|---|---|
| *Cylindrites (Bulla) elongata*, Phil. | [Pl. IV. fig. 7.] | C. O. Malton, Scarborough. |
| *undulata*, Bean, Mag. N. H. 1839, fig. 22. | ............ | C. B. Scarborough. |

### SIPHONOSTOMATA.

#### *Neocomian Species.*

STROMBIDÆ.

| | | |
|---|---|---|
| *Rostellaria* (*Aporrhais*) *Parkinsoni*, Phil. | [Pl. II. figs. 33, 34.] | Upper Clay, Speeton. |
| *retusa*, Sow. (*bicarinata*, Leym.) | ............ | „ „ |

#### *Oolitic Species.*

MURICIDÆ.

| | | |
|---|---|---|
| *Murex Haccanensis*, Phil. ...... | [Pl. IV. fig. 18.] | C. O. Hackness. |

BUCCINIDÆ.

| | | |
|---|---|---|
| *Purpuroidea nodulata*, L. & M. t. 5. f. 1. | ............ | C. O. Malton. |

### CEPHALOPODA.

BELEMNITIDÆ.

#### *Cretaceous and Neocomian Species.*

| | | |
|---|---|---|
| *Belemnitella granulata*, Sow. .. | [Pl. XXV. fig. 2.] | Upper Chalk, Danes' Dike. |
| *mucronata*, Blainv. ...... | [Pl. XXV. fig. 1.] | „ „ |
| *Belemnites Listeri*, Phil. ...... | [Pl. XXV. figs. 3–5.] | Red Chalk, Speeton. |
| *minimus* ............... | [Pl. XXV. fig. 4.] | „ „ |
| *attenuatus* .............. | [Pl. XXV. fig. 6.] | „ „ |

#### *Neocomian Species.*

| | | |
|---|---|---|
| *Belemnites attenuatus*, Sow. .... | [Pl. XXV. fig. 6.] | Upper Clay, Speeton. |
| *jaculum*, Phil. .......... | [Pl. XXV. fig. 7.] | Middle Clay, Speeton. |
| *minimus*, List. .......... | [Pl. XXV. fig. 4.] | Upper Clay, Speeton. |
| *lateralis*, Phil. .......... | [Pl. XXV. fig. 8.] | Lower Clay, Speeton. |
| *Juddii*, Phil. ............ | [Pl. XXV. fig. 9.] | „ „ |

#### *Kimmeridgian Species.*

Mr. Judd quotes *Belemnites Trosloyanus*, D'Orb. and *B. nitidus*, Dollf. Not good specimens.

#### *Species of the Coralline Oolite and Calcareous Grit.*

| | | |
|---|---|---|
| *Belemnites abbreviatus*, Mill. .. | [Pl. XXV. fig. 10.] | C. O. & C. G. Scarborough, Malton. |
| *hastatus*, Bl. (*B. gracilis*, Phil. 1829.) | [Pl. XXVI. figs. 3–5.] | C. G. Scarborough (rare). |

### *Species of the Oxford Clay and Kelloway Rock.*

| | | |
|---|---|---|
| *Belemnites Owenii* (*B. Puzosianus*, D'Orb.). | [Pl. XXVI. fig. 1.] | K. R. Hackness. |
| *tornatilis*, Phil. .......... | [Pl. XXVI. fig. 2.] | „ „ |
| *hastatus*, Bl. (*B. gracilis*, Phil. 1829.) | [Pl. XXVI. figs. 3–5.] | Scarborough. |

### *Species of the Grey Oolite.*

| | | |
|---|---|---|
| *Belemnites Aalensis*, Voltz .... | [Pl. XXVI. fig. 9.] | G. O. White Nab. |
| *anomalus*, Phil. .......... | [Pl. XXVI. fig. 6.] | „ „ |
| *quinquesulcatus*, Blainv. .. | [Pl. XXVI. figs. 7–8.] | „ „ Cloughton, Husthwaite, Carlton. |

### *Supraliassic or Midford Sand Species.*

| | | |
|---|---|---|
| *Belemnites Bucklandi*, Phil. .... | [Pl. XXVII. fig. 13.] | Sandy cap of Lias, Blue Wick. |
| *Milleri*, Phil. .......... | [Pl. XXVII. fig. 12.] | „ „ „ |
| *inornatus*, Phil. .......... | [Pl. XXVII. fig. 10.] | „ „ „ |

## BELEMNITIDÆ.

### *Liassic Species.*

| | | |
|---|---|---|
| *Belemnites acuminatus*, Simpson. | [Pl. XXVIII. fig. 10.] | U. L. & Jet Rock, Saltwick. M. L. Kettleness. |
| *acutus*, Miller .......... | [Pl. XXVIII. fig. 1.] | L. L. Robin Hood's Bay, Redcar. |
| *breviformis*, Voltz ........ | [Pl. XXVIII. fig. ] | M. L. Ironstone, Kettleness, Eston, &c. |
| *claviformis*, Blainv. ...... | [Pl. XXVIII. fig. 4–6.] | M. L. Staithes. L. L. Robin Hood's Bay. |
| *cylindricus*, Simpson...... | [Pl. XXVIII. fig. 14.] | U. L. (lower part). Kettleness, Robin Hood's Bay, &c. M. L. Staithes, Rosedale. |
| *dens*, Simpson .......... | [Pl. XXVIII. fig. 3.] | L. L. Robin Hood's Bay. |
| *dorsalis*, Phil. .......... | [Pl. XXVII. fig. 8.] | U. L. Saltwick. |
| *elegans*, Simpson ........ | [Pl. XXVIII. fig. 11.] | L. L. Robin Hood's Bay, Huntcliff. |
| *elongatus*, Sow.; Phil. Mon. t. 7. f. 17. | ............ | U. L. Whitby (rare). |
| *inæqualis*, Simpson; Phil. Mon. p. 91. (*B. paxillosus numismalis*, Qu.) | ............ | M. L. Staithes &c. |
| *inæquistriatus*, Simpson; Phil. Mon. t. 19. f. 48. | ............ | U. L. Whitby, Runswick. |
| *lævis*, Simpson .......... | [Pl. XXVII. figs. 4–5.] | U. L. Saltwick, Robin Hood's Bay. |
| *latisulcatus*, Phil. ........ | [Pl. XXVII. fig. 1.] | U. L. Whitby. |
| *longisulcatus*, Voltz; Phil. Mon. t. 19. f. 47. | ............ | „ „ |
| *nitidus*, Phil. Mon. t. 13. f. 34 | ............ | L. L. Robin Hood's Bay. |

| | | |
|---|---|---|
| *Belemnites penicillatus*, Sow. . . . . | [Pl. XXVIII. fig. 2.] | L. L. Robin Hood's Bay. |
| *paxillosus*, Schl.; Phil. Mon. t. 6. f. 15. | . . . . . . . . . . . | M. L. Staithes. |
| *pollex*, Simpson . . . . . . . . . . | [Pl. XXVIII. fig. 9.] | U. L. Whitby. L. L. (upp. part). Staithes. |
| *politus*, Simpson . . . . . . . . | . . . . . . . . . . . . | U. L. Jet Rock, Saltwick. |
| *rudis*, Phil. . . . . . . . . . . . . | [Pl. XXVIII. fig. 13.] | M. L. East of Staithes. |
| *striolatus*, Phil. . . . . . . . . . . | [Pl. XXVII. figs. 2, 3.] | U. L. Saltwick, Robin Hood's Bay. |
| *subtenuis*, Simpson . . . . . . | [Pl. XXVII. fig. 6.] | " " " |
| *subaduncatus*, Voltz . . . . . . | [Pl. XXVII. fig. 7.] | U. L. Whitby, Saltwick. |
| *scabrosus*, Simpson . . . . . . | [Pl. XXVIII. fig. 7.] | L. L. Robin Hood's Bay. |
| *tripartitus*, Schl. . . . . . . . . | [Pl. XXVII. fig. 8.] | U. L. Saltwick (Jet Rock). |
| *tubularis*, Y. & B. . . . . . . . . | [Pl. XXVIII. fig. 15.] | U. L. Saltwick, Sandsend. |
| *Voltzii* (*V. conicus* et *ventralis*), Phil. | [Pl. XXVII. fig. 9.] | U. L. Whitby, Saltwick. |
| *vulgaris*, Y. & B. . . . . . . . . | [Pl. XXVII. fig. 11.] | U. L. Whitby Scars, Saltwick, Sandsend. |

### NAUTILIDÆ.

#### *Neocomian Species.*

| | | |
|---|---|---|
| *Nautilus plicatus*, Sow. G. J. ii. 4. p. 129. | . . . . . . . . . . . . | Upper Clay, Speeton. |
| *pseudo-elegans*, D'Orb. t. 8, 9 | . . . . . . . . . . . . | " " |
| *radiatus*, Sow. t. 356 . . . . | . . . . . . . . . . . . | " " |

#### *Oolitic Species.*

| | | |
|---|---|---|
| *Nautilus hexagonus*, Sow. t. 529. | . . . . . . . . . . . . | K. R. Hackness. |
| *lineatus*, Sow. t. 41 . . . . . . | . . . . . . . . . . . . | I. O. Blue Wick. |

#### *Liassic Species.*

| | | |
|---|---|---|
| *Nautilus annularis*, Phil. . . . . . . | [Pl. XII. fig. 18.] | U. L. Whitby. |
| *astacoides*, Simpson . . . . . . | [Pl. XII. fig. 16.] | " " |
| *heterogenus*, Simpson . . . . . . | . . . . . . . . . . . . | L. L. ? ——— |
| *striatus*, Sow. t. 182 . . . . . . | . . . . . . . . . . . . | U. L. Whitby. |

### AMMONITIDÆ.

#### *Cretaceous Species.*

| | | |
|---|---|---|
| *Crioceras Williamsoni*, Phil., a large species, with round volutions transversely and finely ribbed, the ribs meeting two and two in small latero-dorsal rows of tubercles. | . . . . . . . . . . . . | Upper Chalk, Danes' Dike. Unique in the Cabinet of Professor Williamson, 1873. |
| *Scaphites* . . . . . . . . . . . . . . | . . . . . . . . . . . . | One large specimen obtained by Mr. Lee from the Upper Chalk of Danes' Dyke. |
| *Ammonites peramplus*, Sow. . . . . . | . . . . . . . . . . . . | Lower White Chalk, Speeton Cliff (Mr. Wiltshire). |

## *Neocomian Species.*

*Ancyloceras, Crioceras, Hamites, Helicoceras*, a large group of which specimens occur in plenty at Speeton, but seldom in good condition. As regards the costæ, tubercles, and sutures, many of them agree with specimens from the Lower Chalk and Gault of the South of England; but while those are mostly hook-formed, these are mostly spiral, with apparently straight extensions when well-preserved examples occur. The references in ed. ii., under the title of *Hamites*, were chiefly to the species in 'Min. Conch.,' with which the ornamentation seemed to agree. The following was the list:—

| | | |
|---|---|---|
| *Hamites alternatus*, Sow. | [Pl. I. figs. 26, 27.] | *H. armatus*, Sow. (Morris, Cat.). |
| *attenuatus*, Sow. | [Pl. I. fig. 25.] | |
| *Beanii*, Phil. | [Pl. I. fig. 28.] | *Ancyloceras* (Morris, Cat.). |
| *intermedius*, Sow. | [Pl. I. fig. 22.] | |
| *maximus*, Sow. | [Pl. I. figs. 20, 21.] | *Ancyloceras grande*, Forbes (Judd). |
| *Phillipsii*, Bean | [Pl. I. fig. 30.] | *Ancyloceras* (Morris, Cat.). |
| *plicatilis*, Sow. | [Pl. I. fig. 29.] | *A. grande* (Judd). Morris refers it to *H. armatus*, Sow. (*Anisoceras*). |
| *raricostatus*, Phil. | [Pl. I. fig. 23.] | |
| *rotundus*, Sow. | [Pl. I. fig. 24.] | *Helicoceras* (Morris, Cat.). |

Mr. Judd quotes *Crioceras Duvalii*, Leveillé, *C. Emericii*, Leveillé, and *C. Puzozianum*, D'Orb., from Speeton Clay.

| | | |
|---|---|---|
| *Ammonites angulicostatus*, D'Orb. | ............ | Middle Clay. |
| *Asterianus*, D'Orb. | ............ | Lower Clay. |
| *bidichotoma* | ............ | |
| *bipinnatus*, Will. | ............ | Upper Clay. |
| *concinnus*, Phil. | [Pl. II. fig. 47.] | Lower Clay. |
| *crassicostatus*, D'Orb. | ............ | ,, |
| *cryptoceras*, D'Orb. | ............ | Middle Clay. |
| *curvinodus*, Phil. | [Pl. II. fig. 50.] | Upper Clay. |
| *Deshayesii*, Leym. | ............ | ,, |
| *fissicostatus*, Phil. | [Pl. II. fig. 49.] | ,, |
| *hystrix*, Phil. | [Pl. II. fig. 44.] | ,, |
| *marginatus*, Phil. | [Pl. II. fig. 41.] | Upp., Mid., and Low. Clay. |
| *multiplicatus*, Röm. | ............ | Lower Clay. |
| *nisus*, D'Orb. | ............ | Upp., Mid., and Low. Clay. |
| *Noricus*, Schl.* | ............ | Lower Clay. |
| *nucleus*, Phil. | [Pl. II. fig. 43.] | Upp., Mid., and Low. Clay. |
| *parvus*?, Sow. | [Pl. II. fig. 46.] | Middle Clay. |
| *planus*, Mant. | [Pl. II. fig. 42.] | Upper Clay. |
| *plicomphalus*, Sow. t. 359. t. 404. | ............ | K. C. Kirkby Moorside. |
| *rotula*, Sow. | [Pl. II. fig. 45.] | Lower Clay. |
| *Speetonensis*, Y. & B. | ............ | ,, |
| *trisulcosus*, Phil. | ............ | ,, |
| *venustus*, Phil. | [Pl. II. fig. 48.] | ,, |

These statements of distribution are chiefly from Mr. Judd's researches.

* *A. Neocomiensis*, D'Orb. Varieties are named *furcillatus* and *munitus*.

This list, which doubles that given in the earlier editions, includes the determinations of Mr. Judd (G. J. 1868), and retains the names in use before the date of his paper. The opportunities for the complete revision which is needed are much reduced of late years by the separation and, in the case of Mr. Bean, the division of the collections.

## *Ammonites of the Portlandian Beds and Kimmeridge Clay.*

| | | |
|---|---|---|
| *Ammonites alternans*, Von B. t. 7. f. 4. | ............ | K. C. Speeton. |
| *Berryeri* ?, Lesueur ...... | ............ | " " |
| **biplex*, Sow. t. 293 ...... | ............ | P. O. & K. C. Speeton. |
| **giganteus*, Sow. t. 126.... | ............ | P. O. Speeton. |
| **gigas*, Ziet. ............ | ............ | " " |
| **Gravesianus*, D'Orb. .... | ............ | " " |
| **Irius*, D'Orb. .......... | ............ | " " |
| *longispinus*, Sow. ........ | ............ | K. C. Speeton. |
| *Marantianus*, D'Orb. .... | ............ | " " |
| *mutabilis*, Sow. t. 405 .... | ............ | K. C. Kirkby Misperton. |
| **rotundus*, Sow. t. 293 .... | ............ | P. O. & K. C. Speeton. |
| *triplicatus*, Sow. t. 92 .... | ............ | K. C. Speeton. |
| *Yo* ?, D'Orb. ............ | ............ | " " |

## *Coralline, Oolite, and Calc-Grit Species.*

| | | |
|---|---|---|
| *Ammonites cordatus*, Sow. t. 17.. | ............ | C. G. Ashlam, Birdsall. |
| *excavatus*, Sow. .......... | [Pl. VI. fig. 25.] | C. O. Malton. C. G. |
| *perarmatus*, Sow. t. 352 .. | ............ | C. O. Malton. C. G. Cayton Bay, Filey Brig. |
| *plicatilis*, Sow. t. 166 .... | [Pl. IV. fig. 29.] | C. O. Malton, Oswaldkirk. |
| *Sutherlandiæ*, Sow. t. 563.. | ............ | C. O. Malton. C. G. (in balls). Gristhorpe, Scarborough. |
| *varicostatus*, Buckl. G. of Oxf. (*A. instabilis*, Phil. 1829.) | [Pl. XIV. fig. 10.] | C. G. Gristhorpe, Pickering. |
| *vertebralis*, Sow. ........ | [Pl. IV. fig. 34.] | C. O. Malton. C. G. Filey, Cayton. |
| *Williamsoni*, Phil. ...... | [Pl. IV. fig. 19.] | C. O. Ayton. C. G. |

## *Oxford Clay Species.*

| | | |
|---|---|---|
| *Ammonites Lamberti*, Sow. .... | ............ | Scarborough. |
| *oculatus*, Phil. .......... | [Pl. V. fig. 16.] | " |
| *Vernoni*, Bean .......... | [Pl. V. fig. 19.] | " |

* The species thus marked as from the Portland beds are given on the authority of Mr. Leckenby and Mr. Judd.

## *Kelloway Rock Species.*

| | | |
|---|---|---|
| *Ammonites alligatus*, Bean; Leck. p. 2. f. 2 (*A. convolutus*, Quenst.). | ............ | Gristhorpe, Scarborough. |
| *Arduennensis*, D'Orb. .... | ............ | Scarborough. |
| *athleta*, Phil. ............ | [Pl. VI. fig. 19.] | Hackness, Scarborough. |
| *Baugieri*, D'Orb. ........ | ............ | Gristhorpe. |
| *binatus*, Bean .......... | ............ | Scarborough. |
| *bipartitus*, Ziet.......... | ............ | „ |
| *Chamusseti*, D'Orb. (*A. lenticularis*, Phil. 1829.) | [Pl. VI. fig. 25.] | „ |
| *Chauvinianus*, D'Orb. .... | ............ | „ |
| *conterminus*, Bean; Leck. G. J. vol. xv. p. 12. | ............ | „ Gristhorpe. |
| *diversus*, Phil. .......... | [Pl. VI. fig. 18.] | Hackness. |
| *Duncani*, Sow. .......... | [Pl. VI. fig. 16.] | „ |
| *flexicostatus*, Phil......... | [Pl. VI. fig. 20.] | „ Redcliff, Scarborough. |
| *funiferus*, Phil. .......... | [Pl. VI. fig. 23.] | Scarborough. |
| *gemmatus*, Phil. ........ | [Pl. VI. fig. 17.] | „ Hackness, Gristhorpe. |
| *glabellus*, Bean; Leck. G. J. pl. 2. f. 5. | ............ | „ |
| *Gowerianus*, Sow.; Leck. G. J. vol. xv. pl. 1. f. 1. | [Pl. VI. fig. 21.] | Hackness, Scarborough, Redcliff. |
| *gregarius*, Bean; Leck. G. J. vol. xv. p. 11. | ............ | Scarborough. |
| *Gulielmi*, Sow. (young of *Callovicensis*, Phil.). | [Pl. VI. fig. 15.] | Hackness, Gristhorpe, Scarborough. |
| *hyperbolicus*, Simps.; Leck. G. J. vol. xv. pl. 2. f. 4. | ............ | Scarborough, Hackness, Redcliff. |
| *Königi*, Sow. ............ | [Pl. VI. fig. 24.] | Hackness, South Cave, Redcliff. |
| *Lamberti*, Sow. .......... | ............ | Scarborough (Leckenby). |
| *lunula*, Ziet. ............ | ............ | „ |
| *Murrayanus*, Simpson .... | ............ | „ |
| *ordinarius*, Bean; Leck. G. J. vol. xv. p. 8. | ............ | Redcliff. |
| *placenta*, Bean; Leck. pl. 2. f. 1. | ............ | Scarborough. |
| *plicatilis*, Sow. t. 166 .... | ............ | „ (Williamson). |
| *poculum*, Bean; Leck. G. J. vol. xv. pl. 2. f. 4. | ............ | Gristhorpe. |

| | | |
|---|---|---|
| *Ammonites putealis*, Bean; Leck. G. J. vol. xv. pl. 1. f. 3. | ............ | Scarborough. |
| *reversus*, Simps.; Leck. G. J. vol. xv. pl. 2. f. 2. | ............ | ,, |
| *rugosus*, Leck. G. J. vol. xv. p. 9. | ............ | Gristhorpe. |
| *sublævis*, Sow. .......... | [Pl. VI. fig. 22.] | Hackness. |
| *turgidus*, Bean; Leck. G. J. vol. xv. p. 11. | ............ | Scarborough. |
| *vertumnus*, Bean; Leck. G. J. pl. 1. vol. 15. f. 3. | ............ | Gristhorpe. |

This list includes the large additions made in Mr. Leckenby's Memoir, G. J. vol. xv. The references which follow his name are to plates 1 & 2 of that memoir. The locality 'Hackness,' is chiefly from specimens in my collection, which was formerly very large from those now less productive quarries. They were mostly collected by the hands of W. Smith.

### *Cornbrash Species.*

| | | |
|---|---|---|
| *Ammonites Herveyi*, Sow. ...... | ............ | Scarborough. |
| *macrocephalus*, Schl. ...... | ............ | ,, |
| *terebratus*, Phil. .......... | ............ | ,, |

### *Grey Oolite Species.*

| | | |
|---|---|---|
| *Ammonites Humphreysianus*, Sow. | ............ | White Nab. |
| *Blagdeni*, Sow. .......... | ............ | ,, ,, |
| *Parkinsoni*, Sow. ........ | ............ | ,, ,, |

### *Millepore Oolite Species.*

| | | |
|---|---|---|
| *Ammonites Braikenridgii*, Sow... | ............ | |

### *Inferior Oolite (Dogger) Species.*

| | | |
|---|---|---|
| *Ammonites Murchisonæ*, Sow. .. | ............ | In the Ferruginous Oolite, Boltby, near Thirsk. |

### *Liassic Ammonites.*

***Arietes***, Von Buch. Convolute, carinated; a furrow on each side of the keel (except when young), costæ entire.

| | | |
|---|---|---|
| *Ammonites bifrons*, Brug. = *Walcottii*, Sow. t. 106. | ............ | Upper Lias, Whitby, Staithes, &c. |
| *Brookii*, Sow. t. 190 ...... | ............ | |
| *Bucklandi*, Sow. t. 130.... | [Pl. XIV. fig. 13.] | Lower Lias, Redcar. The figure is from a very young individual. |

| | | |
|---|---|---|
| *Ammonites Conybeari*, Sow. t. 131 | [Pl. XIII. fig. 5.] | Lower Lias, Robin Hood's Bay. |
| *multicostatus*, Sow. t. 454 .. | ............ | " " |
| *nodulosus*, Y. & B. t. 12. f. 4 | ............ | " " |
| *obtusus*, Sow. t. 167 ...... | ............ | " " |
| *raricostatus*, Ziet. t. 13 .... | ............ | " " |
| *rotiformis*, Sow. t. 453 .... | ............ | " " |
| *semicostatus*, Y. & B. t. 12. f. 10 (bad). | ............ | |
| *Turneri*, Sow. t. 452...... | [Pl. XIV. fig. 14.] | " " |

The following species, described by Simpson, are from the Lower Lias:—*A. acuticostatus*, S.; *A. aureolus*, S.; *A. Birdi*, S.; *A. impendens*, Y. & B.; *A. latescens*, S.; *A. Levisoni*, S.; *A. multanfractus*, S.; *A. pinguis*, S.; *A. transformatus*, S.; *A. validanfractus*, S.

*Funiferi.* Convolute; carinated; costæ simple and curved.

| | | |
|---|---|---|
| *Ammonites striatulus*, Sow. t. 421 | ............ | U. L. Peak. |
| *Hildensis*, Y. & B......... | ............ | U. L. Jet Rock. |

Simpson describes:—*A. nitescens*, Y. & B. (M. L.); *A. radiatus*, S.; *A. regularis*, S.; *A. rudis*, S.; *A. siphuncularis*, S.; *A. vetustus*, S.—all but the first from Lower Lias.

*Amalthei.* More or less involute, with a crenated keel.

| | | |
|---|---|---|
| *Ammonites crenularis*, Phil. .... | [Pl. XII. fig. 22.] | U. L. Whitby. |
| *Engelhardti*, D'Orb. t. 66 .. | . . ........ | M. L. Staithes. |
| *geometricus*, Phil. ........ | [P. XIV. fig. 9.] | " " |
| *margaritatus*, Montf.; Sow. t. 17. | [Pl. XIV. fig. 6.] | " " |
| *oxynotus*, Quenst. Ceph. t. 5. | ............ | This has rarely a crenated keel (group Clypeiformi). |
| *spinatus*, Brug. .......... | [Pl. XIII. fig. 8.] | M. L. *A. Hawskerensis*, of Y. & B. |
| *Stokesii*, Sow. t. 191 ...... | ............ | M.L. Probably young of *A. margaritatus*. |
| *vittatus*, Y. & B. ........ | [Pl. XIII. fig. 1.] | Supposed to be young of *A. margaritatus*. |

In Simpson's list we find *A. conjunctivus*, S.; *A. depressus*, S.; *A. ferrugineus*, S.; *A. reticularis*, S., from the Middle Lias, which seem to belong to this division.

*Falciferi.* Involute, depressed, sharply carinated, costæ sigmoidal.

| | | |
|---|---|---|
| *Ammonites elegans*, Sow. ...... | [Pl. XIII. fig. 12.] | Whitby. |
| *exaratus*, Y. & B. ........ | [Pl. XIII. fig. 7.] | " |
| *falcifer*, Sow. (*A. mulgravius*, Y. & B.). | ............ | |
| *Lythensis* et *Boulbiensis*, Y.&B. | [Pl. XIII. fig. 6.] | Sandsend, Boulby. |

| | | |
|---|---|---|
| *Ammonites opalinus*, Rein. (*A. ovatus*, Y. & B.). | [Pl. XIII. fig. 10.]. | Saltwick. |

Simpson describes *A. alienus, alternatus, Beanii, Buckii, compactilis, denotatus, dejectus, flavus, Huntoni, lectus, limatus, multifoliatus, obliquatus, Phillipsii, retentus, rugatulus, Robinsoni, simplex, Simpsoni, similis, subconcavus, volutus*, which may be placed in this division though not all strict allies.

*Communes* (Planulati). Convolute, with divided or unequal annular costæ.

| | | |
|---|---|---|
| *Ammonites annulatus*, Sow. t. 222 | ............ | U. L. Sandsend, Runswick. |
| *communis*, Sow. t. 107 .... | ............ | U. L. Whitby, Sandsend. |
| *crassus*, Y. & B. ........ | [Pl. XII. fig. 15.] | U. L. Whitby, Boulby, &c. |

These are nearly allied, especially the three last. To them Simpson adds about twenty more, which, as he remarks, for the most part closely resemble them. They are mostly, if not wholly, from the Upper Lias.

*Armati.* Convolute, costæ unispinose or tuberculated, unequal, dividing, or united. This group is allied to the *Communes*.

| | | |
|---|---|---|
| *Ammonites armatus*, Sow. t. 95 | ............ | L. L. Robin Hood's Bay. |
| *fibulatus*, Sow. t. 407...... | ............ | U. L. Whitby. |
| *subarmatus*, Sow. t. 407 .. | ............ | " " |

Allied to those are more than twenty forms described by Simpson:—*A. Andreæ, aculeatus, armiger, decussatus, hastatus, Hamiltoni, ignotus, mammillatus, miles, mutatus, nativus, obsoletus, Owenensis, retusus, sinuatus. spicatus, subtriangularis, semiarmatus, turriculatus, vortex, vorticellus, validus.* They are mostly from the Lower Lias, while the typical forms best known are from the Upper Lias.

*Biarmati.* Convolute, or partly involute, with round or lunate aperture; costæ unequal (or divided), and bispinose.

| | | |
|---|---|---|
| *Ammonites Birchii*, Sow. ...... | ............ | L. L. Robin Hood's Bay. |
| *brevispina*, Sow. ........ | ............ | " " |
| **heterogeneus*, Y. & B...... | [Pl. XII. fig. 19.] | " " |
| *Bechei*, Sow. ............ | ............ | " " |
| *striatus*, Rein. .......... | ............ | " " |
| *Taylori*, Sow. (*A. cornutus*, S.) | ............ | " " |

Simpson describes *A. quadricornutus, petricosus, Scoresbyi, tenuispina*, which have a general affinity, and are from the Lower Lias.

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* Specimens of this species appears, in the young state, undistinguishable from *A. maculatus*, and in the old state agree with *A. Henleyi* of Sowerby (Wright). The figure referred to represents a ruder variety than is common.

*Capricorni*, Von Buch. Convolute; costæ entire, no keel or furrow.

| | | |
|---|---|---|
| *Ammonites brevispina*, Sow. t. 556 | ............ | L. L. Robin Hood's Bay. |
| *gagateus*, Y. & B. xii. 7. ed. 2 | ............ | U. L. Jet Rock, Saltwick. |
| *Jamesoni*, Sow. t. 555 .... | ............ | L. L. (upper beds). Huntcliff, Robin Hood's Bay. |
| *maculatus*, Y. & B. ....... | [Pl. XIII. fig. 11.] | L. L. (upper beds). Huntcliff. |
| *planicostatus*, Sow. ........ | ............ | L. L. Robin Hood's Bay (Simpson). |

The following species, described by Simpson, seem to belong to this division:—*A. circus, diversus, depressus, figulinus, integricostatus, luridus, neglectus, nitescens, omissus, vitreus*—mostly from the Lower Lias.

*Angulati*. Convolute, at least when young; a furrow or angular inflexion of the costæ on the perimeter (except when very young).

| | | |
|---|---|---|
| *Ammonites arcigerens*, Phil. .... | [Pl. XIII. fig. 9.]. | M. L. Whitby. |
| *anguliferus*, Phil. ........ | [Pl. XIII. fig. 19.] | M. L. Staithes. |
| *angulatus*, Schl.; Quenst. t. 4. f. 2. | ............ | L. L. Redcar, with *Gryphæa incurva*, *Lima gigantea*, and *A. Bucklandi*, J. P. |

One allied species from the Lower Lias is named *A. sulcatus* by Simpson.

*Anguiformes*. Convolute, with aperture nearly round, no keel or furrow.

| | | |
|---|---|---|
| *Ammonites balteatus*, Phil. .... | ............ | U. L. Whitby. |
| *fimbriatus*, Sow. t. 164 (*A. cornucopiæ*, Y. & B.). | ............ | M. N. |
| *Jurensis*, Ziet. .......... | ............ | U. L. Peak. |
| *nitidus*, Y. & B. .......... | ............ | U. L. Whitby. |

Simpson describes *A. anguiformis*, S.; *A. fasciatus*, S.; *A. involutus*, S.; *A. tenuicostatus*, Y. & B.; *A. tubellus*, S. The following appear analogous:—*A. erugatus*, Bean [Pl. XIII. fig. 13]; *A. rutilans*, Bean; *A. Belcheri*, S.; *A. convolutus*, S.; *A. reuspinatus*, S.; *A. exortus*, S.; *A. trivialis*, Bean. They are all from the Lower Lias, and offer points of agreement with *A. polymorphus* of Quenstedt. *A. balteatus* is perhaps the same as *A. nitidus*.

*Nautiloideæ*. Involute, without dorsal keel or furrow.

| | | |
|---|---|---|
| *Ammonites heterophyllus*, Sow. t. 266. | [Pl. XIII. fig. 2.] | U. L. Whitby. |
| *subcarinatus*, Y. & B. .... | [Pl. XIII. fig. 3.] | ,, ,, |
| *Loscombi*, Sow. (*A. ambiguus*, Simpson). | | |

Perhaps this is the best place for the following shells, described by Simpson:—*A. antiquatus, erratus, Easingtonensis, fabricatus, labratus, personatus, peregrinus*, chiefly from Lower Lias. The

small fossils described by the same author, as *A. arctus, Dennyi, nanus*, may perhaps be the young of other larger forms.

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## FISHES.

The following list of Fossil Fishes from the strata of the Yorkshire coast is founded on the collections in the possession of Sir Philip Egerton, Bart., and the Earl of Enniskillen.

Abbreviations used:—Ag. P. F., Agassiz, Poissons Fossiles; Eg. P. G., Egerton, Proceedings of the Geological Society.

### *Neocomian Species.*

| | | |
|---|---|---|
| *Gyrodus minor*, Ag. | [Pl. II. fig. 55.] | Speeton. |
| *Hybodus*, sp., Phil. | [Pl. II. figs. 51–53.] | „ |
| *Macropoma Egertoni*, Ag. P. F. 2. p. 174 | ............ | „ |

### *Oolitic Species.*

| | | |
|---|---|---|
| *Gyrodus*, sp., Phil. | [Pl. IV. fig. 22.] | C. O. Slingsby. |
| *Hybodus*, sp., Phil. | [Pl. V. fig. 22.] | O. C. Scarborough. |
| *Lepidotus*, sp., Phil. | ............ | C. G. Near Howsham. |

### *Species from the Upper Lias.*

| | | |
|---|---|---|
| *Æchmodus ovalis*, Ag. P. F. 2. p. 209 | ............ | Whitby. |
| *Aspidorhynchus anglicus*, Ag. P. F. 2. (2nd ser.) p. 136. | ............ | „ |
| *Belonostomus acutus*, Ag. P. F. 2. (2nd ser.) p. 142 | ............ | „ |
| *Dapedius micans*, Ag. P. F. 2. p. 304 | ............ | „ |
| *Eugnathus fasciculatus*, Ag. P. F. 2. (2nd ser.) p. 105 | ............ | „ |
| *Gyrosteus mirabilis*, Ag. P. F. 2 (2nd ser.) p. 197 | ............ | „ |
| *Lepidotus pectinatus*, Eg. P. G. 1843 | ............ | „ |
| *semiserratus*, Ag. P. F. 2. p. 250 | ............ | „ |
| *Pachycormus acutirostris*, Ag. P. F. 2. (2nd ser.) p. 114. | ............ | „ |
| *curtus*, Ag. P. F. 2. (2nd ser.) p. 114 | ............ | „ |
| *gracilis*, Ag. P. F. 2. (2nd ser.) p. 114 | ............ | „ |
| *latirostris*, Ag. P. F. 2. (2nd ser.) p. 114 | ............ | „ |
| *latus*, Ag. P. F. 2. (2nd ser.) p. 114 | ............ | „ |
| *Pholidophorus*, sp. unnamed | ............ | „ |
| *Ptycholepis Bollensis*, Ag. P. F. 2. p. 108 | ............ | „ |

To these Mr. Simpson adds a species which he names *Tetragonolepis Saltwicensis*, from the same deposits.

## REPTILIA.

The species of *Ichthyosaurus*, *Plesiosaurus*, and *Teleosaurus* which occur in the Yorkshire Lias are mostly confined to the upper parts, and have been principally made known by means of the extensive alum-works on the coast. They appear to be for the most part different from congeneric forms in the Midland and Southern Lias, where the principal repositories are in the lower parts of this great deposit. A few species have been added by different observers since the date of Owen's reports on fossil reptiles, presented to the British Association in 1839 and 1841.

### *Liassic Reptilia*

| | | |
|---|---|---|
| *Ichthyosaurus acutirostris*, Owen, 1839 | [Pl. XII. fig. 2.] | Whitby. |
| *crassimanus*, Owen. Yorkshire Museum | | ,, |
| *intermedius*, Owen, 1839 | | ,, |
| *platyodon*, Con. | | ,, |
| *Plesiosaurus brachycephalus*, Owen | | ,, |
| *Cramptoni*, Carte and Baily, Roy. Dub. Soc. 1839, 1863. | | Kettleness. |
| *homalospondylus*, Owen. Yorkshire Museum | | Whitby. |
| *rugosus*, Owen, 1839 | | ,, |
| *Zetlandi*, Phil. Yorkshire Museum | | Lofthouse. |
| *Teleosaurus Chapmanni*, König; Y. & B. pl. 16. f. 1 | | Whitby. |

### *Oolitic Reptilia.*

| | | |
|---|---|---|
| *Ichthyosaurus*, sp., Phil. | | C. O. Malton. |
| sp., Phil. | | In the Brandsby Roadstone, Yorkshire Museum. |
| *Cetiosaurus* ?, sp., Owen | | In the Grey Limestone of White Nab. Scarbo'. Mus. |
| *Megalosaurus Bucklandi*, Owen | | In the Cor. Oolite, Malton. Yorkshire Museum. |
| *Teleosaurus*, sp., Phil. | | ,, ,, ,, |
| *Plesiosaurus*, sp. | | G. O. Near White Nab. |
| *Pleiosaurus*, sp. | | In Kimmeridge Clay, Speeton. |
| Undetermined Coracoid, Phil. | | Kelloway Rock, Hackness. |

### *Neocomian Reptilia.*

| | |
|---|---|
| *Ichthyosaurus*, sp., Phil. | [Pl. II. figs. 52, 54.] |

## BIRDS—MAMMALIA.

The notices already given in describing the lacustrine beds on the coast, the deposits at Bielbecks (pp. 14–16), in the Pleistocene beds generally (p. 168), and the Cavern of Kirkdale (pp. 168, 169), comprise all the species of Cainozoic Birds and Mammalia in Yorkshire. By Mr. Blake's late explorations at Bielbecks, the fossil Bear (*Ursus arctos*) has been added to the list from that rich locality.

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## NOTE ON HEIGHTS ABOVE THE SEA.

Reference was made (p. 25) to some corrections of the numbers representing heights of cliffs and hills which were given in the first edition. Mr. Gray, my associate on many occasions of scientific research in Yorkshire, has compiled the following list of the principal heights, in East Yorkshire, placing in the first column the numbers formerly assigned, and in the second those now actually expressed on the Ordnance Maps, or inferred from the contour lines. These latter are uniformly from the half or mean tide levels.

| | As in "the Book." | Ordnance (new) Maps. ½ tide? | | As in "the Book." | Ordnance (new) Maps. ½ tide? |
|---|---|---|---|---|---|
| Burton Head | 1485 | 1489 | Three Hows | 820 | 675+ |
| Cranemoor | 1423 | 1427 | Wilton Beacon | 805 | 808 |
| Farndale Head | 1412 | 1391 | Stow Brow (Beacon) | 800 | 873 |
| Loosehoe Moor | 1404 | 1419 | Eaton Nab | 784 | 800 |
| The Two Hows | 1380 | 1379 | Acklam Wold | 739 | 751 |
| Howdale Head | 1346 | 1350 | Bason How | 686 | .... |
| Carlton Bank | 1325 | 1338 | Easington Heights | 681 | 679 |
| Cold Moor | 1314 | 1317 | Rockcliff | 666 | 666 |
| Wainstone | 1300 | 1304 | Flask Inn | 660 | .... |
| Hambleton End | 1300 | 1300+ | Peak | 605 | 600+ |
| Black Hambleton | 1246 | 1234 Δ | Burleigh Moor | 553 | 582 |
| Limekiln House | 1148 | .... | Hunsley Beacon | 531 | .... |
| Boltby Scar | 1105 | .... | Gilling Road | 520 | .... |
| Whitehouse Cliff | 1078 | 1053 | Oliver's Mount | 510 | 500+ |
| Easterside | 1035 | 1048 | Brandsby House Wood | 506 | .... |
| Rosebury Topping | 1022 | 1057 | Scalby Nab | 490 | 500+ |
| Lilhow Cross | 1000 | 978 | Speeton Beacon | 450 | 444 |
| Silhow | 975 | .... | Craike Hill | 400 | .... |
| Danby Beacon | 966 | 988 | Scarbro' Castle | 305 | 285 |
| Oldstead Bank | 954 | 867+ | Gristhorpe Cliff | 295 | 275+ |
| Wass Bank .......... 870 | 900 | 849 or 870 | Flambro' (Lighthouse) | 159 | 154 † |
| Boon Hill | 860 | 834 | Dimlington | 159 | .... |

## List of Fossil Shells from the Post-Tertiary Bed at Bridlington, Yorkshire.

| No. | Authority. | Name of Species. | Synonym. | Where living. | Remarks. |
|---|---|---|---|---|---|
| | | **Brachiopoda.** | | | |
| 1. | W., Wd, W. Jr ... | *Rhynchonella psittacea*, Chemnitz. | .................. | Arctic seas; Shetland; N.E. America; N. Pacific. | |
| | | **Conchifera.** | | | |
| 2. | W., Wd, W. Jr, Y., B. | *Anomia ephippium*, Linné... | .................. | Iceland to Madeira; Labrador to Cape Cod. | |
| 3. | W., Wd, W. Jr, Y., B., L. | *Pecten Islandicus*, Müller ... | .................. | Arctic seas to Bergen; N.E. America; Japan. | Fossil in the Bay of Naples, and at Messina. |
| 4. | W., Wd, W. Jr ... | *Mytilus edulis*, L. ............ | .................. | Throughout the North Atlantic and North Pacific, as well as circumpolar. | A littoral species, and therefore questionable if belonging to this deposit. See note at the end of the list. |
| 5. | W., Wd, W. Jr ... | *Mytilus modiolus*, L. ......... | Genus *Modiola* of some authors. | North Atlantic to Cork; and North Pacific. Not known as polar. Perhaps inhabiting southern seas, but called by other names. | Fossil in Sicily. |
| 6. | W., Wd, W. Jr, Y., B., L. | *Nucula Cobboldiæ*, Leathes... | *N. insignis*, Gould ............ | Japan. | |
| 7. | W., Wd, W. Jr, L. | *Nucula tenuis*, Montagu; and var. *inflata*. | .................. | Spitzbergen to the Ægean; N.E. America; Behrings Straits to Japan. | |
| 8. | W., Wd, W. Jr, L. | *Leda minuta*, Müll.; and var. *buccata*. | *Leda caudata*, Donovan...... | Arctic seas to Bay of Biscay; N.E. America; N.W. America to Japan. | |
| 9. | W., Wd, W. Jr ... | *Leda pernula*, Müll. ......... | .................. | Spitzbergen to Danish coasts. | |
| 10. | W., Wd, W. Jr ... | *Leda limatula*, Say............ | *L. oblongoides*, S. V. Wood; gen. *Yoldia* of some authors. | Arctic seas; N.E. America. | |
| 11. | W., Wd, Y., L. ... | *Pectunculus glycymeris*, L.... | .................. | Loffoden Isles to the Canaries; Japan. | |
| 12. | Coll. Bowerbank (*fide* Forbes). | *Montacuta bidentata*, Mont. | .................. | Norway to Maderia and Sicily. | |
| 13. | W., Wd, W. Jr, Y., L. | *Cardium Islandicum*, L. ... | *C. decorticatum*, S. V. Wood | Arctic seas in both hemispheres; Japan. | |
| 14. | W., Wd, W. Jr, Y. | *Cardium edule*, L. ........... | .................. | Norway to the Caspian and Mediterranean. | Littoral and questionable. Mr. Leckenby says that Mr. Bean's specimens in the York Museum were not from the Bridlington deposit, but "from a bed of sand quite high up in the diluvium near Speeton." |
| 15. | W., Wd, W. Jr, Y., P., L., B. | *Cardita borealis*, Conrad ... | *C. analis*, S. V. Wood, not Philippi. | Mediterranean; N.E. America; Japan. | Specimens much smaller than living or recent specimens. |
| 16. | W., Wd, W. Jr, Y., P., L., B. | *Cyprina Islandica*, L. ...... | .................. | Upper Norway to Arcachon; N.E. America. | Fossil in Sicily. |
| 17. | W., Wd, W. Jr, Y., L., B. | *Astarte sulcata*, Da Costa; and var. *elliptica*. | *Tellina fusca*, Poli; *Venus incrassata*, Brocchi; and many other synonyms. | Spitzbergen to the Mediterranean; N.E. America; N. Pacific. | The variety is *Venus compressa*, L. |

| No. | Authority. | Name of Species. | Synonym. | Where living. | Remarks. |
|---|---|---|---|---|---|
| | | | CONCHIFERA (*continued*). | | |
| 18. | W., W4, W. Jr, L. | *Astarte depressa*, Brown ... | *A. crebricostata*, Forbes; *A. Warhami*, Hancock. | Arctic seas in both hemispheres to north of Hebrides and Cape Cod; Behrings Straits. | |
| 19. | W., Wd, W. Jr, Y., P., L., B. | *Astarte borealis*, Ch.; var. *Withami*; and monstr. *mutabile*. | *Crassina arctica*, Gray; and many other synonyms. | Arctic ocean to Kiel Bay; N.E. America; sea of Ochotsk. | |
| 20. | W., Wd, W. Jr, Y., P., L., B. | *Astarte compressa*, Mont. ... | Many synonyms. Not *Venus compressa* of Linné, which is the variety *elliptica* of *A. sulcata*. | Spitzbergen to coast of Portugal; Baffins Bay to Cape Cod; N. Pacific. | Fossil at Nice according to Risso. |
| 21. | W., Wd, W. Jr, Y., B. | *Venus fluctuosa*, Gould...... | *V. astartoides*, Beck ......... | Arctic seas; N.E. America; sea of Ochotsk; Japan. | |
| 22. | W., Wd, W. Jr, Y., P., L., B. | *Tellina balthica*, L. ......... | *T. solidula*, Pulteney......... | Circumpolar. N. Atlantic to Madeira and Cape Cod; N. Pacific. | |
| 23. | W., Wd, W. Jr, Y., L., B. | *Tellina calcaria*, Ch.; and var. *obliqua*. | *T. lata*, Gmelin; *T. proxima*, Brown; and many other synonyms. | Spitzbergen to the Baltic; Greenland to Cape Cod; Behrings Straits to Japan. | |
| 24. | L. & J. G. J. ...... | *Donax vittatus*, Da C. ...... | *D. trunculus*, L. (partim); *D. semistriatus*, Poli. | Upper Norway to Mediterranean. | Purchased. |
| 25. | Wd, W. Jr, L., B. | *Mactra solida*, L.; var. *elliptica*. | .................. | Iceland to Bay of Biscay. | |
| 26. | Y..................... | *Thracia prætenuis*, Pulteney | .................. | Ireland to Sicily. | |
| 27. | Y., P. .............. | *Corbula gibba*, Olivi ......... | *C. nucleus*, Lamarck ......... | Loffoden Isles to the Canaries and Ægean. | |
| 28. | W., W. Jr, Y...... | *Mya arenaria*, L. ........... | *M. Japonica*, Jay ........... | Arctic seas to Adriatic; N.E. America; N. Pacific. | |
| 29. | W., Wd, W. Jr, Y., L., B. | *Mya truncata*, L. ........... | .................. | Same range of distribution... | Fossil in Sicily. |
| 30. | W., Wd, W. Jr, P., L., B. | *Saxicava Norvegica*, Spengler | Genus *Panopæa* of some authors. | Iceland to Dogger Bank; N.E. America; N. Pacific. | Fossil in Sicily. |
| 31. | W., Wd, W. Jr, Y., P., B. | *Saxicava rugosa*, L. ......... | *Mya arctica*, L. ............... | Universally distributed. | |
| 32. | W., Wd, W. Jr, Y., P., L., B. | *Pholas crispata*, L. ........... | .................. | Iceland to Bay of Biscay; N.E. America; N. Pacific. | |
| | | | SOLENOCONCHIA. | | |
| 33. | B..................... | *Dentalium entalis*, L......... | .................. | Iceland to Bay of Biscay; N. Pacific. | Fossil in Sicily. |
| 34. | W., Wd, W. Jr, Y., P., L., B. | *Dentalium striolatum*, Stimpson. | *D. abyssorum*, Sars; var. *D. incertum*, Philippi = *D. agile*, Sars. | Arctic seas to Bay of Biscay; N.E. America; var. *incerta*, Mediterranean. | |
| | | | GASTROPODA. | | |
| 35. | L ... .............. .. | *Lepeta cæca*, Müll. ............ | .................. | Arctic seas to Hebrides, N.E. and N.W. America. | |
| 36. | W., Wd, W. Jr, L., B. | *Puncturella noachina*, L. ... | .................. | Arctic seas to Bay of Biscay; N.E. America; N. Pacific. | Fossil in Sicily. |
| 37. | W., Wd, W. Jr, Y., L., B. | *Trochus varicosus*, Mighels and Adams. | *Margarita elegantissima*, Bean and other synonyms. | Spitzbergen to Norway; N.E. America; Japan. | |

GASTROPODA (*continued*).

| No. | Authority. | Name of Species. | Synonym. | Where living. | Remarks. |
|---|---|---|---|---|---|
| 38. | W., Wd, W. Jr, P. | *Littorina litorea*, L. ........ | .................. | Arctic ocean to the Adriatic; N.E. America. | Littoral and questionable. |
| 39. | L. & J. G. J. ...... | *Littorina rudis*, Maton ...... | Numerous synonyms ......... | Arctic seas to Azores and Adriatic; N.E. America; Japan. | Purchased; perhaps adventitious, being a littoral species. |
| 40. | W., Wd, W. Jr, Y., P. | *Turritella terebra*, L. ......... | *T. communis*, Risso ......... | Loffoden Isles to the Adriatic | |
| 41. | W., Wd, W. Jr, Y., L., B. | *Turritella erosa*, Couthouy... | *T. clathratula*, S. V. Wood *T. polaris*, Beck. | Arctic seas; N.E. America. | |
| 42. | W., Wd, W., Jr, Y., L., B. | *Scalaria Groenlandica*, Ch. . | .................. | Arctic ocean to north of Hebrides; N.E. America. | |
| 43. | W., Wd, W. Jr., Y., L. | *Natica Islandica*, Gmelin ... | *N. helicoides*, Johnston ...... | Arctic ocean to Cork; N.E. America. | |
| 44. | W., Wd, W. Jr, Y., P., L., B. | *Natica Groenlandica*, Beck... | .................. | Arctic ocean to Straits of Gibraltar; N.E. America; N. Pacific. | |
| 45. | W., Wd, W. Jr, Y., L., B. | *Natica affinis*, Gm.; and var. *occlusa*. | *N. clausa*, Broderip & Sowerby; var. *occlusa* = *N. russa*, Gould. | Arctic ocean to the Bay of Biscay; N.E. America; N. Pacific. | |
| 46. | W., Wd, W. Jr ... | *Natica Montacuti*, Forbes ... | .................. | Iceland and Loffoden Isles to Straits of Gibraltar. | Fossil in Sicily and Rhodes. |
| 47. | W., Wd, W. Jr, Y., L., B. | *Trichotropis borealis*, Brod. & Sow. | .................. | Arctic seas in both hemispheres, to the Dogger Bank and west of Ireland on the one side and the Massachusetts coast on the other side of the Atlantic. | |
| 48. | W., Wd, W. Jr, Y., L., B. | *Admete viridula*, Fabricius... | *Cancellaria costellifera*, J. Sowerby. | Spitzbergen to Bay of Biscay; N.E. America; Japan. | |
| 49. | Wd., W. Jr, P., L. . | *Purpura lapillus*, L ........ | .................. | Arctic seas to Mogador; N.E. America; N. Pacific. | |
| 50. | W., Wd?, W. Jr, Y., P., L. | *Buccinum undatum*, L. ...... | .................. | North Cape and Iceland to Rochelle; N.E. America; N. Pacific. | Fossil in Calabria and Sicily. |
| 51. | Wd, W. Jr, L., B... | *Trophon truncatus*, Ström... | .................. | Greenland to south of Ireland; N.E. America. | |
| 52. | W., Wd, W. Jr, Y., P., L., B. | *Trophon clathratus*, L.; and var. *Gunneri*. | *T. scalariformis*, Gould...... | Arctic seas in both hemispheres; Japan. | |
| 53. | W., Wd, W. Jr, P., L. | *Trophon Fabricii*, Beck...... | *Murex craticulatus*, Fabr.; not *T. craticulatus*, L. | Arctic seas in both hemispheres. | |
| 54. | L..................... | *Trophon latericeus*, Müll. ... | .................. | Arctic ocean to north of Hebrides. | |
| 55. | W., Wd, W. Jr, P., L., B. | *Fusus despectus*, L.; and monstr. *contrarium*. | .................. | Arctic ocean to coasts of Portugal; N. Pacific. | |
| 56. | W., L. .............. | *Fusus Leckenbyi*, S. V. Wood | *Fusus turgidulus*, Jeffreys MS. | Deep water between Shetland and the Faroë I. | |
| 57. | W., Wd, W. Jr, Y., P., L., B. | *Fusus curtus*, Jeffr.; and var. *expansa*. | *Trophon gracile*, *Sabini*, and *ventricosus*, S. V. Wood. | N.E. America. | |
| 58. | B..................... | *Fusus Spitzbergensis*, Reeve | *F. Sabini*, Woodward ...... | Spitzbergen and Wellington channel. | |
| 59. | W., Wd, W. Jr...... | *Fusus propinquus*, Alder ... | .................. | If this species, Loffoden Isles to Dogger Bank. Möbius gives a high northern latitude (73°–74°); but its occurrence at Bridlington requires verification. | Very questionable. |
| 60. | L..................... | *Fusus Sarsi*, Jeffr. .......... | .................. | Norway to south of Faroë I. in deep water. | |
| 61. | W., Wd, W. Jr, B. | *Columbella rosacea*, Gould... | *C. Holböllii*, Beck. ........... | Spitzbergen to north of Hebrides; N.E. America. | |

| No. | Authority. | Name of Species. | Synonym. | Where living. | Remarks. |
|---|---|---|---|---|---|
| | | GASTROPODA (*continued*). | | | |
| 62. | W., W$^d$, W. J$^r$, Y., B. | *Pleurotoma pyramidalis*, Str. | *Fusus pleurotomarius*, Couth. | Spitzbergen to Bergen; Greenland to Cape Cod. | |
| 63. | W., W$^d$?, W. J$^r$, L., B. | *Pleurotoma violacea*, Migh. and Ad. | *Defrancia cylindracea* (Beck), Möller. | Arctic ocean to Norway; N.E. America; Wellington Channel. | |
| 64. | W., W$^d$, W. J$^r$, L. | *Pleurotoma elegans*, Möller | .................. | Spitzbergen. | |
| 65. | W., W$^d$, W. J$^r$, Y., P., L., B. | *Pleurotoma turricula*, Mont.; and vars. *nobilis* and *exarata*. | *P. Dowsoni*, S. V. Wood, and other synonyms for varieties. | Spitzbergen to the Straits of Gibraltar; N.E. America; Japan. | |
| 66. | W., L. ............... | *Pleurotoma harpularia*, Couth. | *P. robusta*, S. V. Wood ...... | Norway to N.E. America. | |
| 67. | W$^d$, W. J$^r$, Y., P., L., B. | *Pleurotoma Trevelyana*, Turt. | *Defrancia Woodiana*, Moll. . | Arctic seas in both hemispheres to Dogger Bank and Cape Cod; N.W. America. | |

N.B. In the second column, B. signifies British Museum; L. Mr. Leckenby's collection at Cambridge; P., collection of Professor Phillips at Oxford; W., Mr. S. V. Wood's Monograph of the Crag Mollusca and Supplements published by the Palæontographical Society; W. J$^r$., Mr. S. V. Wood, Jun., paper in the Quarterly Journal of the Geological Society for 1870, p. 92, "On the Relation of the Boulder-clay, without Chalk, of the North of England to the Great Chalky Boulder-Clay of the South;" W$^d$, Mr. S. P. Woodward's "Remarks on the Bridlington Crag, with a list of its fossil shells" (Geological Magazine, vol. i. p. 49, 1864); Y., Collection in the Museum of the Philosophical Society at York.

All the above-named species are now living and inhabit the arctic and northern seas. *Nucula Cobboldiæ* is hitherto known from Japan only; but it is probable that when the coralline and deep-sea zones of the circumpolar ocean shall have been explored, this species and many others, which are supposed to have a limited distribution, will be discovered in the highest latitudes. Whether the Bridlington deposit was caused by a deviation of the arctic current in ancient times, or whether the nature of its fauna necessarily implies that glacial conditions then existed in that part of Europe, is a question which requires careful attention. The present direction of the arctic current has been to a certain extent shown by the expeditions in H.M.S. 'Porcupine' during the years 1869 and 1870, to traverse the North Atlantic along the west coast of Ireland as well as the Bay of Biscay; and there is no doubt that it formerly reached that part of the Mediterranean where Sicily is.

I should be inclined to reject from the list of Bridlington shells the following species, viz. *Mytilus edulis*, *Cardium edule*, *Littorina litorea*, *L. rudis*, and *Purpura lapillus*; because they are littoral, and therefore not likely to be associated with species which belong to the Coralline zone, such as *Rhynchonella psittacea*, *Venus fluctuosa*, *Dentalium striolatum*, *Admete viridula*, and *Columbella Holbölli*. These littoral shells may have come from an overlying or adjacent bed, and become accidentally mixed with the shells from the deposit under consideration.

28 March, 1874. J. GWYN JEFFREYS.

# OOLITIC FORAMINIFERA OF ENGLAND.

COMPILED BY

T. RUPERT JONES, F.R.S.

| | | |
|---|---|---|
| *Nodosariæ* .............. | A.N.H. 3. iii. 479, 3. v. 114. | "Kimmeridge and Oxford Clays." |
| *Nodosaria* (*Glandulina*) *lævigata*. | Phil. Trans. clv. 341; A. N. H. 2. xix. 281. | "Oxford Clay, Leighton &c.; Kimmeridge Clay, Aylesbury." |
| *radicula* ............ | Phil. Trans. clv. 341 .... | "Clays of the Oolites." |
| *Dentalina communis*........ | Phil. Trans. clv. 342 .... | "Jurassic Clays." |
| *Vaginulina linearis*, allies of. | Phil. Trans. clv. 343 .... | "Clays of the Secondary Formations." |
| *Marginulina*.............. | Phil. Trans. clv. 344 .... | "Secondary strata." |
| Minute *Marginuliua Wetherellii*. | A. N. H. 3. iv. 349 ...... | "Clays of the Oolites." |
| *Cristellaria rotulata* ........ | A. N. H. 2. xix. 291 .... | "Some of the Oolites." |
| *rotulata* ............ | Phil. Trans. clv. 345 .... | "Secondary deposits." |
| *crepidula* ............ | Phil. Trans. clv. 344 .... | " " |
| *Polymorphina lactea* ...... | Tr. Linn. Soc. xxvii. 215.. | "Kimmeridge Clay, Kimmeridge." |
| *gibba* .............. | Tr. Linn. Soc. xxvii. 218.. | "Kimmeridge Clay." |
| *compressa* ............ | Tr. Linn. Soc. xxvii. 229.. | "Oxford Clay, Oxford, and Kimmeridge Clay, Kimmeridge." |
| *compressa*, vars. ...... | Phil. Trans. clv. 362 .... | "Secondary deposits." |
| *Bolivina punctata*.......... | Phil. Trans. clv. 376 .... | "Oxford Clay and Kimmeridge Clay." |
| *Virgulina Schreibersii*, vars.. | Phil. Trans. clv. 375 .... | "Clays of the Oolite." |
| *paradoxa* ............ | A. N. H. 4. ix. 299 ...... | "Jurassic Clays." |
| *Textilaria* (*Spiroplecta*) *annectens*. | A. N. H. 3. xi. 92 ...... | "Clays of the Oolites." |
| *Textilariæ*, small; *Verneuilinæ*, large ....... | A. N. H. 3. xi. 96 ...... | "Some clays of the Oolites." |
| *Planorbulina ammonoides* and vars. | Phil. Trans. clv. 384 .... | "Secondary deposits." |
| *Pulvinulina elegans*, var..... | Phil. Trans. clv. 390 .... | "Kimmeridge Clay." |
| *Karsteni*, var. ........ | Phil. Trans. clv. 397 .... | "Kimmeridge Clay and Oxford Clay." |
| *repanda*, vars. ........ | A. N. H. 3. v. 176 ...... | "Clays of the Oolites." |
| *Lituola* .................. | A. N. H. 2. xix. 302 .... | "Oxford Clay." |
| *Placopsilina* .............. | A. N. H. 2. xix. 302 .... | "Inferior Oolite, on *Ostræa flabelloides* (*Marshii*), Peterborough." |

Numerous other forms are as yet undescribed.

In furtherance of a request made by the late Prof. Phillips, the following local lists of the Oolitic Foraminifera have been made by Professors W. K. PARKER and RUPERT JONES from their own collections. The materials were in part supplied by Prof. Phillips himself:—

1. Upper Portland Limestone, Ridgeway, Dorset.

*Lagena globosa.*
*Cristellaria rotulata.*
*Trochammina*: combining characters of *Tr. gordialis* and *Tr. incerta*: low-conical, subtranslucent.

2. Kimmeridge Clay, Aylesbury.

*Glandulina.*
*Nodosaria.*
*Dentalina.*
*Vaginulina harpa.*
*Marginulina.*
*Cristellaria.*
*Planularia.*
*Lituola*: nautiloid.
Polyzoon (*Lepralia*).

3. *Ostrea deltoidea* bed; lower part of the Kimmeridge Clay, at the base of Shotover Hill, Oxford.

*Dentalina.*
*Vaginulina harpa* and *V. lævigata.*
*Marginulina.*
*Cristellaria.*
*Planularia.*
*Flabellina.*
*Frondicularia.*
*Lituola* (*Placopsilina*): attached, creeping: straightish.
*Lituola globigeriniformis.*

4. Upper Oxford Clay, Oxford.

*Orthocerina* (*Rhadogonium*): triangular.
*Lingulina*: some with a terminal Nodosarian chamber.
*Dentalina*: very delicate and long.
*Vaginulina harpa.*
*Marginulina.*
*Cristellaria.*
*Planularia.*
*Flabellina.*
*Frondicularia.*
*Lituola*: straight, lituate, and nautiloid.

5. Oxford Clay, Ridgeway, Dorset.

*Marginulina.*
*Cristellaria.*
*Pulvinulina caracolla.*
*Lituola*: nautiloid and lituate.

### 6. Shelly Clay, Great Oolite, 1½ mile North of Peterborough.

*Nodosaria.*
*Dentalina.*
*Vaginulina harpa* and *V. strigilata.*
*Marginulina.*
*Planularia.*
*Cristellaria.*
*Flabellina.*
*Frondicularia.*

*Textilaria* ........... } Comparable with a recent group from the Abrolhos.
*Verneuilina* ..........
*Lituola*: straight, lituate, and nautiloid ....
*Trochammina* (*Webbina*): creeping, attached, on shell.
—— *incerta*: both sandy and subtranslucent.
*Nubecularia*: long, moniliform, attached, on shell.

### 7. Lias (or Inferior Oolite?) Clay at 150 feet, New England, 1½ mile north of Peterborough.

*Cristellaria.*
*Pulvinulina* (between *P. elegans* and *P. caracolla*): abundant and small.

*Lituola scorpiurus* (dentaline and neat).
*Trochammina incerta.* (*T. elliptica*: oblong-oval.)

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I am indebted to the courtesy of Mr. Harland, of Sawdon Park Cottage, Brompton, for much useful information regarding the alternating clays and gravels which underlie the flat surface of the Vale of Pickering. By five artesian borings from 68 to 95 feet deep the succession and thickness of these drift-beds has been fully made out along a great part of the Vale between Sherburn and Malton. Each of these experiments was successful in discovering a bed of gravel and sand with water which rose above the surface 5, 6, 10, 16, or 20 feet, from depths of 68, 79, 80½, 90, and 95 feet respectively. This gravel usually on being tapped contained chalk; it was penetrated in one case to a depth of 2½ feet. The beds immediately above the gravel was in each situation clay, usually thick (30, 49, 55 feet); in one case it was very thin, and succeeded by 50 feet of alternating sands, gravel, and shale. At the surface, in one instance, peat 3 feet thick was met with. The water obtained was soft with distinct traces of iron.

Probably the drift-deposits filling the old sea-loch extend to a greater depth than that reached in the deepest boring, which is in the middle of the vale near Yeddingham, at a point less than 100 feet above the sea-level; if these drifts were removed, and the boulder-clays of Filey pierced, the old loch would be reestablished, and the vale resume its preglacial aspect.

If the success of these trials should induce others, it is very desirable that specimens of sand, clays, and gravels should be preserved for a careful examination, which might determine some of the local conditions under which the deposits were accumulated.

# APPENDIX.

**List of Books, Papers, Maps, &c. on the Geology, Mineralogy, and Palæontology of Yorkshire.** By William Whitaker, B.A. (Lond.), of the Geological Survey of England.

The following list contains the titles of 616 different papers, &c. by 290 authors, arranged according to the years of their publication, from 1626 to the present time.

Owing to the great difficulty of finding copies of provincial publications in London libraries there may be many omissions, a note of which will much oblige the writer, who, however, trusts that no work of great importance has escaped notice.

The earlier works consist largely, as might be expected, of books on mineral waters, and a knowledge of many of these has been got from the very full list in Baines's 'Yorkshire Library;' but some works therein mentioned are not included in this list, as not in any way bearing on geology.

The writer owes his thanks to his colleague Mr. W. Topley, for drawing his attention to some papers which he had omitted to notice.

INDEX OF AUTHORS, WITH THE NUMBERS OF THEIR PAPERS, &c.

## LIST OF WORKS.

1626.

1. Dean, Dr. E. Spadacrene Anglica, the English Spaw, or, the Glory of Knaresborough, &c. (Chap. ii. Earths, Stones, &c.) ? Another ed. in 1649. 4to. *York*. Ed. 2 in 1654. 12mo. *York*. Another ed. in 1736. 8vo. *Leeds*.

1632.

2. Stanhope, M. Cures without Care ........ by vertue of Minerall waters neare Knaresborow ........ 4to. *Lond.*

1652.

3. French, Dr. J. The York-shire Spaw, or a Treatise of four Famous Medicinal Wells, ...... near Knaresborow. 12mo. *Lond.* Reprinted, under the title "A Pocket Companion for Harrowgate Spaw," in 1760. 8vo. *Halifax*.

1660.

4. Wittie, Dr. R. Scarbrough Spaw: or a Description of the Nature and Vertues of the Spaw at Scarbrough in Yorkshire. 12mo. *York*. Another ed. in 1667.

1669.

5. Simpson, Dr. W. Hydrologia Chymica, or the Chymical Anatomy of Scarbrough and other Spaws in Yorkshire. 8vo. *Lond.*
6. Wittie, Dr. R. Pyrologia Mimica, or, an Answer to Hydrologia Chymica. 12mo. *Lond.*

1670.

7. Simpson, Dr. W. Hydrological Essays: or a Vindication of Hydrologia Chymica: Being a Further Discovery of the Scarbrough Spaw and of the Sweet Spaw and Sulphur-Well at Knaresborough: With a brief Account of the Allom Works at Whitby. 12mo. *Lond.*
8. Tonstall, Dr. G. Scarbrough Spaw spagyrically anatomized. 12mo. *Lond.*

1671.

9. Lister, [Dr.] M. A Letter ........ on that of M. Steno concerning Petrify'd shells [sees that different beds have different shells, differing from recent species]. *Phil. Trans.* vol. v. no. 76, p. 2282.

1672.

10. Tonstall, Dr. G. A New-years-gift for Doctor Witty; or the Dissector anatomized. 12mo. *Lond.*

11. WITTIE, Dr. R. Scarbrough's Spagyrical Anatomizer dissected. 12mo. *Lond.*

1674.

12. LISTER, [Dr.] M. A Description of certain Stones figured like Plants, and by some Observing men esteemed to be Plants petrified. *Phil. Trans.* vol. viii. no. 100, p. 6181.

1675.

13. ———. Of an odd figured Iris. *Phil. Trans.* vol. ix. no. 110, p. 222.
14. ———. Glossoptera tricuspis non-serrata (Malton, &c.). *Ibid.* p. 223.
15. ———. Of certain Dactili Idæi, or the true Lapides Judaici, for kind found with us in Britain (Malton, &c.). *Ibid.* p. 224.
16. ———. A Letter containing his Observations of the Astroites; or Star-stones. *Ibid.* vol. x. no. 112, p. 274.
17. SYMPSON, Dr. W. Zymologia Physica......with an additional Discourse of the Sulphur-bath at Knaresborough. 12mo. *Lond.*

1679.

18. COLWALL, D. An Account of the English Alum-Works. *Phil. Trans.* vol. xii. no. 142, p. 1052.
19. SIMPSON, Dr. W. The History of Scarbrough Spaw (the rarities observable at Scarbrough, pp. 119 &c.). 12mo. *Lond.*

1693.

20. LISTER, Dr. M. An Account of certain transparent Pebbles, mostly of the shape of the Ombriæ or Brontiæ (Scarborough). *Phil. Trans.* vol. xvii. no. 201, p. 778.

1697.

21. RICHARDSON, Dr. —. Part of a Letter containing a Relation of Subterraneous Trees, Dug up at Youle in Yorkshire. *Phil. Trans.* vol. xix. no. 228, p. 526.

1699.

22. ALLEN, B. The Natural History of the Chalybeat and Purging Waters of England. 8vo. *Lond.* And under the title "The Natural History of the Mineral-Waters of Great-Britain." 8vo. *Lond.* in 1711.
23. LISTER, Dr. M., and — MALEVERER. Of Coal-Borings. *Phil. Trans.* vol. xxi. no. 250, p. 73.

1701.

24. DE LA PRYME, Rev. A. Part of a Letter concerning Trees found under Ground in Hatfield Chace. *Phil. Trans.* vol. xxii. no. 275, p. 980, and vol. xxiii. no. 277, p. 1073 (1702).

1734.

25. SHORT, Dr. T. The Natural, Experimental, and Medicinal History of the Mineral Waters of Derbyshire, Lincolnshire, and Yorkshire, particularly those of Scarborough,...... Together with the Natural History of the Earths, Minerals, and Fossils through which the chief of them pass. 4to. *Lond.*

1735.

26. ANON. [? Dr. P. SHAW]. A Dissertation on the Contents, Virtues, and Uses, of Cold and Hot Mineral Springs; particularly those of Scarborough. 8vo. *Lond.*

1737.

27. ATKINS, J. A Compendious Treatise on the Contents ...... of Cold and Hot Mineral Springs in general, particularly the celebrated Hot Waters of Scarborough. 8vo. *Lond.*

1746.

28. KNOWLTON, T. An Account of Two extraordinary Deer Horns, found under-ground in different Parts of Yorkshire. *Phil. Trans.* vol. xliv. part 1. no. 479, p. 124.

1758.

29. DA COSTA, E. M. An Account of the Impressions of Plants on the Slates of Coals (partly from Robin Hood Bay). *Phil. Trans.* vol. l. p. 228.

1759.

30. CHAPMAN, Capt. W. An Account of the fossile Bones of an Alligator, found on the Sea-shore, near Whitby in Yorkshire. *Phil. Trans.* vol. l. part 2, p. 688.

31. WOOLLER, —. A Description of the fossil Skeleton of an Animal found in the Alum Rock near Whitby. *Ibid.* p. 786.

1765.

32. ANON. [Dr. T. SHORT]. A General Treatise on various Cold Mineral Waters in England, but more particularly on those at Harrogate, Thorp-Arch, &c. 8vo. *Lond.*

1774.

33. JARS, M. G. Voyages Metallurgiques, tome i. (York, p. 255). 4to. *Lyons.*

1779.

34. CHARLTON, L. The History of Whitby &c. (Account of the Soils, Waste of Coast, Curiosities, &c., pp. 351–357.) 4to. *York.*

1781.

35. ANON. Tour to the Caves in the Environs of Ingleborough and Settle, in the West Riding of Yorkshire, their Geology, &c. 8vo. (? A German book.)

36. JARS, M. G. Voyages Metallurgiques, tome iii. (York, pp. 72, 287). 4to. *Paris.*

1782.

37. WILLAN, Dr. R. Observations on the Sulphur-water at Croft, near Darlington. 8vo. *Lond.* Ed. 2, under a different title, in 1786.

1784.

38. WALKER, Dr. J. An Essay on the Waters of Harrogate and Thorp-Arch in Yorkshire. 8vo. *Lond.*

1786.

39. [WATSON ?] (R., Bishop of Llandaff). Observations on the Sulphur Wells at Harrogate. *Phil. Trans.* vol. lxxvi. p. 171.

1788.

40. MARSHALL, W. The Rural Economy of Yorkshire (Soils &c., vol. i. pp. 298–301, vol. ii. pp. 241, 275). 8vo. *Lond.*

1789.

41. WATSON, R. Chemical Essays (Observations on the Sulphur Wells at Harrogate, Springs in Yorkshire). 12mo.

1790.

42. Garnett, Dr. T. Experiments and Observations on the Horley Green Spaw near Halifax. 8vo. *Bradford.*

1791.

43. ———. Experiments and Observations on the Crescent Water at Harrogate. 8vo. *Leeds.*

1792.

44. ———. A Treatise on the Mineral Waters of Harrogate. 8vo. *Lond.* Ed. 2 in 1794, ? another ed. in 1804, Ed. 5 in 1810, Ed. 7 in 1822, Ed. 8 in 1829.

1794.

45. Leatham, I. General View of the Agriculture of the East Riding of Yorkshire (Map and Account of Soils). 4to. *Lond.*

46. Tuke, J. General View of the Agriculture of the North Riding of Yorkshire (Map and Account of Soils). 4to. *Lond.*

1796.

47. Outram, B. Particulars of the Discovery of some very singular Balls of Stone, found in the Works of the Huddersfield Canal. *Phil. Trans.* vol. lxxxvi. p. 350.

1798.

48. Hinderwell, T. The History and Antiquities of Scarborough and the Vicinity (Landslip, p. 174. Scarborough Spaws, pp. 182–191. Petrefactions &c. by W. Travis, pp. 213–215). 4to. *York.* Ed. 2, 8vo. *Lond.*, in 1811. Another ed., 8vo. *Scarborough*, 1832.

1799.

49. Alderson, Dr. J. Geological Observations on the Vicinity of Hull and Beverley. *Journ. of Nat. Phil. Chem. and Arts* (4to), vol. iii. p. 285.

50. Tennant, S. On different Sorts of Lime used in Agriculture. *Phil. Mag.* vol. v. p. 209.

1800.

51. Housman, J. A Topographical Description of Cumberland, Westmoreland, Lancashire, and a part of the West Riding of Yorkshire (Map of the Soils, Accounts of Caves, Soils, Minerals, &c.). 8vo. *Carlisle.* Part reprinted, under the title "Descriptive Tour &c." in 1808 (ed. 3), in 1814 (ed. 6), in 1816 (ed. 7), and in 1817 (ed. 8).

1804.

52. Miller, Dr. E. The History and Antiquities of Doncaster and its Vicinity (Stone quarries, Gypsum, Minerals, &c., pp. 9–11). 4to. *Doncaster.*

1805.

53. Sheffield, W. E. Catalogue of Minerals found in Craven. Appendix II. p. 12 of Dr. T. Whitaker's 'History and Antiquities of Craven, in the county of York.' 4to. *Lond.*

1806.

54. Belcombe, Dr. W., and W. Travis. "General Account of Scarborough Spaw Waters," and "Fossils," pp. 21–29 and 100–103 of 'The Scarborough Guide,' by W. Ainsworth. Ed. 3, 16mo. *York.* Ed. 5, 16mo. *Scarborough*, in 1812?

1807.

55. Ribblesdale, Lord. Account of a Mine of Zinc Ore, and its Application as a Paint. *Trans. Soc. Arts*, p. 35, and *Journ. Nat. Phil. Chem. and Arts*, ser. 2, vol. xxi. p. 12 (1808).

1809.

56. Cayley, Dr. G. Synoptical Tables, shewing the component parts of the Principal Mineral Waters. 8vo. *Ripon.*

57. Forster, W. A Treatise on a section of the Strata commencing near Newcastle upon Tyne and concluding on the west side of Cross Fell. With remarks on Mineral Veins in general. To which are added tables of the Strata in Yorkshire, Derbyshire, &c. 8vo. *Newcastle.* Ed. 2, 8vo. *Alston*, in 1821.

1810.

58. Farey, J. On the supposed Fresh-water Origin of the Gypsum Strata in the Environs of Paris; on the Geological Characters and Relations of the Alum Shales on the Northern Coasts of Yorkshire, &c. *Phil. Mag.* vol. xxxv. p. 256.

59. ———. A List of about Five Hundred Collieries in and near to Derbyshire. *Ibid.* p. 431.

1811.

60. Farey, J. A List of about 280 Mines of Lead,—some with Zinc, Manganese, Copper, Iron, Fluor, Barytes, &c. in and near to Derbyshire. *Phil. Mag.* vol. xxxvii. p. 106.

61. ———. A List of about 700 Hills and Eminences in and near to Derbyshire, with the Stratum which occupies the top of each, and other Particulars. *Ibid.* pp. 161, 443.

1812.

62. Anon. (F. O. E.). On Gypsum near Doncaster, and Nodules of Limestone, and of Pyrites containing Sea Shells in the Coal district near Bradford in Yorkshire. *Phil. Mag.* vol. xxxix. p. 352.

63. Farey, J. An Account of the Great Derbyshire Denudation (refers to Yorkshire). *Ibid.* p. 26.

64. ———. Geological Observations in Correction and Addition to the Paper on the Great Derbyshire Denudation...... relating principally to Coal-measures near to the Chalk strata; the Course of the 3rd and 4th Grit Rocks and Crowstone through Yorkshire, and the Termination of its Coal-field northward: the limits of the Yellow Lime Rock and the Existence of Red Marl, Gypsum Beds, Strontian, &c. between its Rocks, &c. *Ibid.* p. 93.

65. ———. [Letter in reply to M. De Luc.] (Coal-plants, Yorkshire, p. 516.) *Monthly Mag.* vol. xxxiii. no. 228, p. 513.

1812–1815.

66. Sowerby, J. The Mineral Conchology of Great Britain. Vol. i. (Yorkshire, pp. 34, 84, 131, 132, 210, 215). 8vo. *Lond.*

1813.

67. Anon. (J. W. M.). Transition Rocks in Yorkshire. *Ann. of Phil.* vol. ii. p. 148.

68. FAREY, J. Cursory Geological Observations lately made in...... Yorkshire, N.R...... and on the supposed Identity of the Derbyshire Peak and the Craven Limestone Rocks. *Phil. Mag.* vol. xlii. p. 53.

69. GOUGH, J. Observations on the Ebbing and Flowing Well, at Giggleswick, in the West Riding of Yorkshire, with a theory of Reciprocating Fountains. *Mem. Lit. and Phil. Soc. Manchester*, ser. 2, vol. ii. p. 354.

1815.

70. FAREY, J. Short Notices of Geological Observations made in the Summer of 1814, in the South of Yorkshire, and in North Wales, and of some Inferences therefrom, as to the Structure of England and Wales. *Phil. Mag.* vol. xlv. p. 161.

71. STORER, Dr. J. On an ebbing and flowing stream discovered by boring in the harbour of Bridlington. *Phil. Trans.* vol. cv. part 1, p. 54, and *Phil. Mag.* vol. xlv. p. 432.

1816.

72. ANON. [F. KENDALL]. A Descriptive Catalogue of the Minerals, and Fossil Organic Remains of Scarborough and the Vicinity. 8vo. *Scarborough.*

73. ——— [WINCH, N. J.]. Answer to the Geological Queries of a Constant Reader (refers to Whitby). *Phil. Mag.* vol. xlvii. p. 100.

1816–1818.

74. SOWERBY, J. The Mineral Conchology of Great Britain, vol. ii. (Yorkshire, pp. 9, 10, 86, 123). 8vo. *Lond.*

1817.

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76. ———. Answer to the Geological Theories by N. J. Winch, Esq., &c. *Ibid.* p. 250.

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# EXPLANATION OF THE PLATES.

The former editions included a geological map of the eastern part of Yorkshire, intended to convey a correct general idea of the relative situation and extent of the principal mineral masses; the scale to which it was drawn did not allow of minute accuracy. In 1853 my larger map in greater detail was published, including the whole county; and to that reference may be conveniently made, even after the issue of the more exact maps on a large scale now in preparation by the Geological Survey*.

The specimens figured in the following Plates were chiefly in the Collections of the Yorkshire Museum, Mr. Bean, Mr. Williamson (since transferred to the Scarborough Museum), Dr. Murray, and the Author; a few were drawn from the cabinets of Mr. Ripley, Mr. Lee, Mr. Cook, Mr. Preston, and the Whitby Museum, as indicated by the name after each species. The Bean collection has been divided between the British Museum, the Yorkshire Philosophical Society, and Mr. Leckenby, who has since transferred his fine series of Yorkshire fossils to the Museum of the University of Cambridge. Mr. Cook's collection is now placed in the Yorkshire Museum.

The changes of nomenclature since 1829 require in many instances two designations for the same fossil, viz. the name usually referred to as being employed in the former editions, and that adopted in conformity with modern usage in the lists already given in this volume. Two columns of names are arranged to show the extent of the alterations. The first gives the reference as it stood in the former editions; the second contains that now sanctioned, chiefly through the work of Mr. Etheridge. If the difference is only generic, the name of the preferred genus only is given; the occasional necessary change of termination in the specific names (to suit the gender in Latin) is not treated as a change of name. The dotted line indicates that no change is made.

* The eastern portion of this Map, or that relating to and illustrating this part of the Geology of Yorkshire, has been re-engraved, recoloured, and reproduced in this edition; it was felt that this would materially add to the usefulness and value of the late Professor's work, especially so as the map above named was his own, and also his latest views upon the Geology of the eastern area.—R. Etheridge.

## PLATE I.—Chalk Fossils.

| Fig. | Reference, 1829. | Reference, 1874. | In what Collection. |
|---|---|---|---|
| 1. | *Spongia plana* ............. | ................ | Lee. |
| 2. | *capitata* ............... | ................ | Author. |
| 3. | *osculifera* ............. | *Manon* .................... | York. |
| 4. | *Benettiæ* ............... | *Cephalites* ................. | ,, |
| 5. | *marginata* ............. | *Manon* .................... | ,, |
| 6. | *convoluta* ............... | *Chenendopora* ................ | ,, |
| 7. | *cribrosa* ............... | *Scyphia* .................... | Author. |
| 8. | *porosa* ................. | *Coscinopora* ................ | York. |
| 8*a*. | *lævis*, with magnified parts of surface. | ,, ............... | Author. |
| 9. | *radiciformis* ........... | *Hippalimus* .................. | ,, |
| 10. | *terebrata*, with magnified view of interior. | *Siphonia* .................... | York. |
| 11. | *Lunulites urceolata* ........... | *Coscinopora pileolus* .......... | ,, |
| 12. | *Millepora globularis* .......... | *Coscinopora* ................ | ,, |
| 13. | *Caryophyllia centralis* ........ | *Parasmilia* .................. | ,, |
| 14. | *Marsupites ornatus* ........... | ................ | ,, |
| 14*a*. | Plate of *Cidaris papillata* or *cretosa* | *Cyphosoma Königi* ............ | Lee. |
| 15. | *Spatangus planus* ........... | *Holaster* .................... | Bean. |
| 16. | *hemisphæricus* ........... | ,, .................... | Williamson. |
| 17. | *Terebratula pentagonalis* (compare it with *T. striatula*, Pl. II. fig. 28). | *Terebratulina striata* .......... | York. |
| 18. | *Belemnites Listeri* ........... | ................ | ,, |
| 19. | *Serpula* ................... | *Serpula solitaria* ........... | ,, |

## Speeton Clay.

| Fig. | Reference, 1829. | Reference, 1874. | In what Collection. |
|---|---|---|---|
| 20. 21. | *Hamites maximus*. It is a fine spiral shell. | *Ancyloceras grande* ........... | Cook. |
| 22. | *intermedius* ............. | ................ | Bean. |
| 23. | *raricostatus* ............. | ................ | Williamson. |
| 24. | *rotundus* ............... | *Helicoceras* ................. | Cook. |
| 25. | *attenuatus* ............. | ................ | Bean. |
| 26. 27. | *alternatus* ............. | ................ | ,, |
| 28. | *Beanii** ............... | *Ancyloceras* ................. | ,, |
| 29. | *plicatilis* ............... | ,, ................. | Williamson. |
| 30. | *Phillipsii** ............. | ,, ................. | Bean. |

## PLATE II.—Speeton Clay.

| Fig. | Reference, 1829. | Reference, 1874. | In what Collection. |
|---|---|---|---|
| 1. | *Caryophyllia conulus* .......... | *Trochocyathus* ................ | York. |
| 2. | *Cidaris* ................... | ................ | Williamson. |
| 3. | Muricated spine of *Cidaris* .... | ................ | ,, |
| 4. | *Spatangus argillaceus* .......... | *Toxaster* .................... | ,, |
| 5. | Granulated spine of *Cidaris* .... | ................ | Cook. |

## Plate II.—Speeton Clay (*continued*).

| Fig. | Reference, 1829. | Reference, 1874. | In what Collection. |
|---|---|---|---|
| 6. | *Corbula punctum* | ................ | York. |
| 7. | *Tellina* | ................ | " |
| 8. | *Mya depressa* | *Thracia Phillipsii* | " |
| 9. | *Pholadomya decussata* | ................ | " |
| 10. | *Nucula ovata* | ................ | " |
| 11. | *subrecurva* | ................ | " |
| 12. | *Nucula* | ................ | " |
| 13. | *Mya phaseolina* | ................ | Bean. |
| 14. | *Lutraria* | ................ | York. |
| 15. | *Lucina sculpta* | ................ | Williamson. |
| 16. | *Cucullæa* | *Cucullæa securis* | Bean. |
| 17. | *Pholas constricta* | ................ | Preston. |
| 18. 19. | *Astarte lævis* | ................ | Williamson. |
| 20. 21. | *Isocardia angulata* | ................ | York. |
| 22. | *Pinna gracilis* | ................ | Preston. |
| 23. | *Gryphæa sinuata* | *Exogyra* | York. |
| 24. | *Terebratula inconstans.* Kim. Clay | *Rhynchonella* | " |
| 25. 26. | *subundata* | *Terebratula obtusa* | " |
| 27. | *lineolata* | *Rhynchonella* | Bean. |
| 28. | *striatula* | *Terebratulina Martiniana* | York. |
| 29. | *Vermicularia Sowerbii* | ................ | " |
| 30. | *Serpula* | ................ | " |
| 31. | *Dentalium* | ................ | Williamson. |
| 32. | *Delphinula?* | *Delphinula inconspicua* | York. |
| 33. 34. | *Rostellaria Parkinsoni* | ................ | " |
| 35. | *Turbo pulcherrimus* | *Trochus* | " |
| 36. | *Solarium tabulatum* | ................ | Bean. |
| 37. | *Trochus reticulatus?* | ................ | York. |
| 38. | *Turritella?* | *Cerithium Phillipsii* | " |
| 39. | *Melania?* | ................ | Bean. |
| 40. | *Auricula obsoleta* | *Avellana* | " |
| 41. | *Ammonites marginatus* | ................ | York. |
| 42. | *planus* | ................ | " |
| 43. | *nucleus* | ................ | " |
| 44. | *hystrix* | ................ | Bean. |
| 45. | *rotula* | ................ | York. |
| 46. | like *A. parvus* | ................ | " |
| 47. | *concinnus* | ................ | " |
| 48. | *venustus* | ................ | " |
| 49. | *fissicostatus* | ................ | Williamson. |
| 50. | *curvinodus* | ................ | Wilson. |
| 51. | Tooth of *Squalus?* | ................ | " |
| 52. | Tooth of *Ichthyosaurus* | ................ | " |
| 53. | Tooth of *Squalus?* | ................ | York. |
| 54. | Vertebra of *Ichthyosaurus* | ................ | " |
| 55. | *Gyrodus minor* | ................ | Preston. |

## Plate III.—Speeton Clay.

| Fig. | Reference, 1829. | Reference, 1874. | In what Collection. |
|---|---|---|---|
| 1. | *Belemnites jaculum* | ................ | Author. |
| 2. | *Astacus ornatus* | *Meyeria* | „ |
| 3. | Claw of *Astacus mucronatus* | *Meyeria* ? | Bean. |

## Coralline Oolite.

| Fig. | Reference, 1829. | Reference, 1874. | In what Collection. |
|---|---|---|---|
| 4. | *Turbinolia dispar* | *Montlivaltia* | York. |
| 5. | *Caryophyllia cylindrica* | *Thecosmilia* | „ |
| 6. | *Astræa tubulifera* | *Stylina* | „ |
| 7. | *favosoïdes* | *Isastræa* | „ |
| 8. | *Spongia floriceps* | ................ | „ |
| 9. | Radical part of *Rhodocrinus echinatus.* | ................ | „ |
| 10. | The column with bifid side-arms | ................ | „ |
| 11. | The column with the cicatrices of side-arms. | ................ | Williamson. |
| 12. | *Cidaris florigemma* | ................ | York. |
| 13. | Muricated spine of *Cidaris florigemma.* | ................ | „ |
| 14. | Smooth spine of *Cidaris intermedia* | *Hemicidaris* | „ |
| 15. | *Echinus germinans* | *Stomechinus* | „ |
| 16. | *Clypeus dimidiatus* | *Echinobrissus* | „ |
| 17. | *semisulcatus* | *Pygaster* | „ |
| 18. | *emarginatus* | *Clypeus subulatus* | „ |
| 19. | *Pholas recondita* | ................ | Cook. |
| 20. | *Modiola inclusa* | *Lithodomus* | York. |
| 21. | *Astarte extensa* | ................ | „ |
| 22. | *aliena* | ................ | „ |
| 23. | *Cardita similis* | *Opis Phillipsii* | „ |
| 24. | *Tellina ampliata* | ................ | „ |
| 25. | *Astarte ovata* | ................ | „ |
| 26. | *Trigonellites antiquatus* | ................ | „ |
| 27. | *Corbula curtansata* | *Tancredia* | „ |
| 28. | *Isocardia rhomboidalis* | *Astarte* | „ |
| 29. | *Arca æmula* | ................ | „ |
| 30. | *Cucullæa contracta* | ................ | „ |
| 31. | *triangularis* | *Sowerbya* | „ |
| 32. | *pectinata* | ................ | „ |
| 33. | *elongata* ? | ................ | „ |
| 34. | *oblonga* | ................ | „ |
| 35. | *Avicula expansa* (lower valve) | ................ | „ |
| 36. | *ovalis* (lower valve) | ................ | „ |

## Plate IV.—Coralline Oolite.

| Fig. | Reference, 1829. | Reference, 1874. | In what Collection. |
|---|---|---|---|
| 1. | *Ostrea duriuscula* ........... | ................ | Bean. |
| 2. | *Avicula elegantissima* .......... | ................ | „ |
| 3. | *Cardium lobatum* ........... | ................ | Williamson. |
| 4. | *Nucula* .................. | ................ | York. |
| 5. | *Psammobia lævigata* .......... | *Quenstedtia* .................. | Bean. |
| 6. | *Gryphæa? mima* ........... | ................ | Williamson. |
| 7. | *Bulla elongata* ............. | ................ | „ |
| 8. | *Turritella muricata* .......... | *Cerithium* ................. | „ |
| 9. | *Natica cincta* .............. | ................ | Leeds. |
| 10. | *Pecten inæquicostatus* ......... | ................ | York. |
| 11. | *Turbo funiculatus* ........... | *Littorina*.................. | „ |
| 12. | *Orbicula radiata*............. | *Discina* .................. | „ |
| 13. | *Terebra melanioïdes* .......... | *Chemnitzia* ................. | „ |
| 14. | *Turbo muricatus*............. | *Littorina* .................. | „ |
| 15. | *Serpula squamosa* ........... | ................ | Bean. |
| 16. | *Trochus tornatilis* ........... | *Trochotoma* ................. | Williamson. |
| 17. | *Vermicularia compressa* ........ | ................ | Bean. |
| 18. | *Murex Haccanensis* .......... | ................ | Williamson. |
| 19. | *Ammonites Williamsoni* ........ | ................ | „ |
| 20. 21. | *Astacus rostratus* ........... | *Glyphæa*.................... | York. |
| 22. | Palatal teeth of a fish ........ | ................ | „ |

## Calcareous Grit.

| Fig. | Reference, 1829. | Reference, 1874. | In what Collection. |
|---|---|---|---|
| 23. | *Spatangus ovalis*............. | *Collyrites bicordata* .......... | Bean. |
| 24. | *Clypeaster pentagonalis* ........ | *Pygurus* .................... | „ |
| 25. | *Isocardia tumida* ........... | *Isocardia tenera* ............. | Williamson. |
| 26. | *Venus* ..................... | ................ | „ |
| 27. | *Actæon retusus* ........... | ................ | „ |
| 28. | *Cirrus cingulatus* ........... | *Pleurotomaria*............... | Bean. |
| 29. | *Ammonites solaris* (erased 1874) | *Am. plicatis* (replacing *A. solaris*) | Williamson. |
| 30. | *Modiola bipartita* ........... | ................ | York. |
| 31. | *Pholadomya simplex* ......... | ................ | „ |
| 32. | *Rostellaria bispinosa* .......... | *Alaria*..................... | Williamson. |
| 33. | *Pinna lanceolata*............. | ................ | York. |
| 34. | *Ammonites vertebralis*.......... | ................ | „ |
| 35. | *Serpula lacerata* ............ | ................ | Williamson. |
| 36. | *Gryphæa bullata?* ............ | *Gryphæa dilatata* ........... | York. |
| 37. | *Dentalium* ................. | *Dentalium entaloideum* ........ | Williamson. |

## Plate V.—Oxford Clay.

| Fig. | Reference, 1829. | Reference, 1874. | In what Collection. |
|---|---|---|---|
| 1. | *Sanguinolaria undulata* ........ | *Anatina* .................... | York. |
| 2. | *Astarte lurida*................ | *Astarte ungulata*............. | „ |
| 3. | *carinata* ............... | ................ | „ |
| 4. | *Nucula* (cast) ............... | ................ | „ |

## PLATE V.—Oxford Clay (*continued*).

| Fig. | Reference, 1829. | Reference, 1874. | In what Collection. |
|---|---|---|---|
| 5. | *Nucula nuda* ................ | ................ | York. |
| 6. | *elliptica* ................ | ................ | Bean. |
| 7. | *Pinna mitis* ................ | ................ | York. |
| 8. | *Trigonellites politus* .......... | ................ | " |
| 9. | *Cucullæa concinna* ............ | ................ | Bean. |
| 10. | *Plagiostoma* ................ | *Lima argillacea* .............. | " |
| 11. | *Pecten* ...................... | *Pecten cingulatus* ............ | York. |
| 12. | *Ostrea* ...................... | ................ | Williamson. |
| 13. | *inæqualis* .............. | *Placunopsis* .................. | Bean. |
| 14. | *Rostellaria trifida* ............ | *Alaria* ...................... | York. |
| 15. | *Belemnites gracilis* ............ | ................ | " |
| 16. | *Ammonites oculatus* .......... | ................ | Bean. |
| 17. | *Ammonites* .................. | ................ | York. |
| 18. | Unknown .................. | *Pollicipes concinnus* .......... | Bean. |
| 19. | *Ammonites Vernoni* .......... | ................ | York. |
| 20. | Claw of *Astacus* .............. | ................ | Bean. |
| 21. | *Serpula intestinalis* ............ | ................ | Williamson. |
| 22. | Tooth of *Squalus*? ............ | ................ | " |

## Kelloway Rock.

| Fig. | Reference, 1829. | Reference, 1874. | In what Collection. |
|---|---|---|---|
| 23. | *Mya* ...................... | ................ | York. |
| 24. | *Pholadomya obsoleta* .......... | ................ | " |
| 25. | *Amphidesma recurvum* ........ | *Myacites* .................... | " |
| 26. | *Modiola pulchra* .............. | ................ | " |
| 27. | *Cardium dissimile*? .......... | *Cardium fallax* .............. | " |
| 28. | Variety of *Modiola cuneata*? .... | ................ | " |
| 29. | *Corbis ovalis* ................ | *Corbicella* .................. | Bean. |
| 30. | *Astarte* .................... | *Cyprina depressiuscula* ........ | York. |
| 31. | *Cucullæa concinna* ............ | ................ | " |
| 32. | *Corbis lævis*? ................ | *Corbicella* .................. | " |

## PLATE VI.—Kelloway Rock.

| Fig. | Reference, 1829. | Reference, 1874. | In what Collection. |
|---|---|---|---|
| 1. | *Gryphæa dilatata*, var. $\beta$ ...... | ................ | York. |
| 2. | *Plagiostoma duplicatum* (cast) .. | *Lima* ...................... | Bean. |
| 3. | *Pecten fibrosus* .............. | ................ | " |
| 4. | *Ostrea undosa* ................ | ................ | " |
| 5. | *Pecten demissus* .............. | ................ | " |
| 6. | *Avicula Braamburiensis* ........ | ................ | York. |
| 7. | *Terebratula ornithocephala* ...... | ................ | " |
| 8. | *socialis* ................ | *Rhynchonella* ................ | " |
| 9. | *Ostrea archetypa* .............. | ................ | " |
| 10. | *Turbo sulcostomus* ............ | ................ | " |
| 11. | *Lucina lirata* ................ | ................ | Author. |
| 12. | *Cirrus depressus* .............. | *Pleurotomaria* .............. | Bean. |
| 13. | *Rostellaria bispinosa* .......... | ................ | Williamson. |

## PLATE VI.—Kelloway Rock (*continued*).

| Fig. | Reference, 1829. | Reference, 1874. | In what Collection. |
|---|---|---|---|
| 14. | *Trochus guttatus* | | Williamson. |
| 15. | *Ammonites Calloviensis*, juv. | *Gulielmi* | York. |
| 16. | *Duncani* | | " |
| 17. | *gemmatus* | | Author. |
| 18. | *bifrons* | *diversus* | " |
| 19. | *athleta* | | " |
| 20. | *flexicostatus* | | " |
| 21. | *Gowerianus* | | " |
| 22. | *sublævis* | | " |
| 23. | *funiferus* | | " |
| 24. | *Kœnigi* | | " |
| 25. | *lenticularis* | *Chamusseti* | " |

## PLATE VII.—Cornbrash.

| | | | |
|---|---|---|---|
| 1. | *Cidaris vagans* | *Pseudodiadema* | York. |
| 2. | *Clypeus clunicularis* | *Echinobrissus* | " |
| 3. | *orbicularis* | " | Author. |
| 4. | *Galerites depressus* | *Holectypus* | York. |
| 5. | *Mya literata* | *Goniomya* | " |
| 6. | *Isocardia minima?* | | " |
| 7. | *Cardium citrinoïdeum* | | " |
| 8. | *Cellaria Smithii* | *Hippothoa* | " |
| 9. | *Pholadomya Murchisoni* | *Pholadomya Phillipsii* | " |
| 10. | *Amphidesma securiforme* | *Myacites* | " |
| 11. | *decurtatum* | " | " |
| 12. | *Unio peregrinus* | *Gresslya* | " |
| 13. | *Plagiostoma rigidulum* | *Lima* | " |
| 14. | *interstinctum* | " | Williamson. |
| 15. | *Melania vittata* | *Chemnitzia* | " |
| 16. | *Terebra granulata* | *Nerinæa* | " |

## Middle Sandstone, Shale, and Coal.

| | | | |
|---|---|---|---|
| 17. | *Sphenopteris? longifolia* | *Cyclopteris* | Bean. |
| 18. | *? latifolia* | *Cyclopteris digitata* | " |
| 19. | *Cycadites tenuicaulis* | *Pterophyllum* | " |
| 20. | *comptus* | " | York. |
| 21. | *sulcicaulis*. Detached figures of the upper and under sides of the base of the leaf. | *Ctenis falcata* | Dr. Murray. |
| 22. | *pecten* | *Pterophyllum* | Bean. |
| 23. | Unknown leaves | | " |
| 24. | leaf | *Taxites laxus* | " |
| 25. | Small vegetable bodies in groups | | " |

## Plate VIII.—Middle Sandstone, Shale, and Coal.

| Fig. | Reference, 1829. | Reference, 1874. | In what Collection. |
|---|---|---|---|
| 1. | Spike of *Lycopodites* .......... | *Walchia Williamsonii* ........ | Bean. |
| 2. | Winged seed ................ | ................ | ,, |
| 3. | *Lycopodites uncifolius* ........ | *Walchia Williamsonii* ........ | Williamson. |
| 4. | *Aspleniopteris Nilssoni?* ........ | *Pterophyllum* ................ | Bean. |
| 5. | *Scolopendrium solitarium* ...... | *Tæniopteris vittata* ............ | York. |
| 6. | *Sphænopteris digitata* .......... | *Sphænopteris Williamsoni* ...... | Williamson. |
| 7. | Variety of ditto .............. | ................ | ,, |
| 8. | *Pecopteris paucifolia* .......... | *Glossopteris Phillipsii* ........ | Bean. |
| 9. | *Phyllites nervulosus* .......... | *Phlebopteris Phillipsii* ........ | ,, |
| 10. | *Pecopteris cæspitosa* .......... | ................ | ,, |
| 11. | *crenifolia* .............. | *Phlebopteris* .................. | ,, |
| 11 *a*. | Magnified seed-vessels ........ | ................ | ,, |
| 12. | *Pecopteris curtata*, with a granulated surface. | ................ | ,, |
| 13. | *Neuropteris lobifolia* .......... | *Pecopteris* .................. | Preston. |
| 14. | *Pecopteris ligata* .............. | ................ | York. |
| 15. | *recentior* ................ | ................ | Williamson. |
| 16. | *exilis* .................. | ................ | York. |
| 17. | *hastata* ................ | *Pecopteris Whitbiensis* ........ | Williamson. |
| 18. | A skeletonized fern-branch .... | ................ | Bean. |

## Plate IX.—Grey Oolite and Millepore Oolite.

| Fig. | Reference, 1829. | Reference, 1874. | In what Collection. |
|---|---|---|---|
| 1. | *Millepora straminea* .......... | *Spiropora* (*Cricopora*) ........ | York. |
| 2. | *Retepora?* .................. | ................ | ,, |
| 3. | Smooth spine of *Cidaris* ...... | *Heterocidaris Wickensis* ........ | ,, |
| 4. | Muricated spine of *Cidaris* .... | ................ | ,, |
| 5. | Spine of *Cidaris maxima* ...... | *Rhabdocidaris* ................ | ,, |
| 6. | *Lutraria gibbosa?* ............ | *Myacites Scarburgensis* ........ | Bean. |
| 7. | *Pholadomya nana* ............ | ................ | ,, |
| 8. | *Lucina despecta* .............. | ................ | ,, |
| 9. | *Isocardia angulata?* .......... | ................ | ,, |
| 10. | *nitida* ................ | ................ | ,, |
| 11. | *Nucula variabilis* ............ | ................ | ,, |
| 12. | *Cytherea dolabra* (small specimen) | ................ | ,, |
| 13. | *Pullastra recondita* ............ | *Astarte* .................. | ,, |
| 14. | *Cardium cognatum* ............ | ................ | ,, |
| 15. | *semiglabrum* ............ | ................ | ,, |
| 16. | *Corbula depressa* ............ | *Unicardium* ................ | ,, |
| 17. | *Pinna cuneata* .............. | ................ | ,, |
| 18. | *Terebratula spinosa* ............ | *Rhynchonella* ................ | York. |
| 19. | *Cucullæa imperialis* .......... | ................ | Bean. |
| 20. | *cylindrica* ............ | ................ | Phil. |
| 21. 22. | *Perna quadrata* .............. | *Perna rugosa* ................ | Williamson. |
| 23. | *Astarte minima* .............. | ................ | York. |
| 24. | *Cucullæa cancellata* .......... | ................ | Bean. |

## PLATE IX.—Grey Oolite and Millepore Oolite (*continued*).

| Fig. | Reference, 1829. | Reference, 1874. | In what Collection. |
|---|---|---|---|
| 25. | *Nucula lachryma* (obtuse variety) | ................ | York. |
| 26. | *Gryphæa* ................ | ................ | " |
| 27. | *Terebra vetusta* ............ | *Chemnitzia* ................ | Williamson. |
| 28. | *Rostellaria composita* ......... | *Alaria Phillipsii* ........... | Bean. |
| 29. | *Phasianella cincta* ........... | ................ | " |
| 30. | *Natica adducta* ............. | ................ | " |
| 31. | *Actæon glaber* .............. | *Actæonina* ................ | " |
| 32. | *Delphinula?* ............... | ................ | York. |
| 33. | *Trochus monilectus* ........... | ................ | Bean. |
| 34. | *Vermicularia nodus* .......... | ................ | York. |
| 35. | *Ostrea sulcifera* ............ | ................ | " |
| 36. | *Gervillia acuta* ............ | ................ | " |
| 37. | *Pecten abjectus* ............ | *Hinnites* ................ | " |
| 38. | *Belemnites quinquesulcatus* ...... | ................ | " |

## PLATE X.—Lower Sandstone, Shale, and Coal.

| | | | |
|---|---|---|---|
| 1. | *Cycadites latifolius* ........... | *Otozamites* ................ | York. |
| 2. | *gramineus* ............ | " ................ | " |
| 3. | *lanceolatus* ........... | " ................ | " |
| 4. | *pectinoides* ............ | *Pterophyllum* ............... | " |
| 5. | Winged seed .............. | *Araucarites* ............... | Phil. |
| 6. | *Sphænopteris lanceolata* ....... | *Dichopteris* ................ | York. |
| 7. | *Pecopteris curtata* .......... | ................ | " |
| 8. | *Sphænopteris stipata* ......... | *Sphænopteris hymenophylloides* .. | " |
| 9. | *Neuropteris lævigata* ......... | *Dichopteris* ................ | " |
| 10. | *Sphænopteris muscoides* ....... | ................ | " |
| 11. | *Thuites expansus?* ........... | ................ | " |
| 12. | *Flabellaria? viminea* ......... | *Selenites Murrayana* .......... | " |
| 13. | *Equisetum laterale* ........... | ................ | " |

## PLATE XI.—Inferior Oolite.

| | | | |
|---|---|---|---|
| 1. | *Caryophyllia convexa* ........ | *Montlivaltia* ............... | Bean. |
| 2. | *Cidaris* ................ | ................ | " |
| 3. | *Mya calceiformis* ........... | *Myacites* ................ | " |
| 4. | *dilata* ................ | " ................ | " |
| 5. | *Cardium incertum* ........... | ................ | Whitby. |
| 6. | *acutangulum* ............ | *Cypricardia cordiformis* ....... | Bean. |
| 7. | *striatulum* ............ | ................ | " |
| 8. | *gibberulum* ............ | ................ | " |
| 9. | Variety of *Modiola aspera?* .... | *Modiola furcata* ............. | " |
| 10. 11. | *Astarte* ................ | ................ | " |

## PLATE XI.—Inferior Oolite (*continued*).

| Fig. | Reference, 1829. | Reference, 1874. | In what Collection. |
|---|---|---|---|
| 12. | *Mya æquata* | *Myacites* | Bean. |
| 13. | *Nucula axiniformis* | *Tancredia* | " |
| 14. | *lachryma* | *Leda anglica* | " |
| 15. | *Pullastra oblita* | *Quenstedtia* | " |
| 16. | *Gervillia lata* | ................ | " |
| 17. | Hinge of ditto | ................ | " |
| 18. | *Cucullæa reticulata* | ................ | " |
| 19. | *Nucula variabilis* | ................ | York. |
| 20. | *Pecten virguliferus* | ................ | Bean. |
| 21. | *Mytilus cuneatus* | ................ | Ripley. |
| 22. | *Trochus pyramidatus* | ................ | Bean. |
| 23. | *Turritella quadrivittata* | *Cerithium* | " |
| 24. | *Lingula Beanii* | ................ | York. |
| 25. | *Natica tumidula* | ................ | Bean. |
| 26. | *Serpula deplexa* | ................ | York. |
| 27. | *Trochus bisertus* | ................ | Williamson. |
| 28. | *Turritella cingenda* | *Nerinæa* | York. |
| 29. | Mouth of ditto | " | " |
| 30. | *Solarium calix* | *Trochotoma* | " |
| 31. | *Turbo lævigatus* | ................ | Bean. |
| 32. | *Nerita costata* | *Neritopsis pseudocostata* | York. |
| 33. | *Auricula Sedgvici* | *Actæon* | Bean. |
| 34. | *Actæon humeralis* | ................ | " |
| 35. | *Natica adducta* | ................ | York. |
| 36. | *Gastrochæna tortuosa* | *Gervillia* | " |
| 37. | *Vermicularia compressa* | ................ | " |
| 38. | *Trigonia striata* | ................ | " |
| 39. | *Cardita similis* | *Opis* | " |
| 40. | *Isocardia concentrica* | *Ceromya Bajociana* | " |
| 41. | *Astarte elegans* | ................ | " |
| 42. | *Unio abductus* | *Gresslya* | " |
| 43. | *Cucullæa elongata* | *Macrodon Hirsonensis* | Bean. |
| 44. | *cancellata* | ................ | " |

## PLATE XII.—Upper Lias Shale.

| | | | |
|---|---|---|---|
| 1. | Basal and posterior view of the cranium of a small Crocodile. | ................ | York. |
| 2. | Lateral view of the head of Saurian animal: a vertical aperture on the head? | ................ | " |
| 3. | *Corbis uniformis.* | ................ | " |
| 4. | *Nucula ovum* | *Leda* | " |
| 5. | *Amphidesma donaciforme* | *Myacites* | " |
| 6. | *rotundatum* | " | " |
| 7. | *Cardium* (cast) | ................ | Author. |

## PLATE XII.—Upper Lias Shale (*continued*).

| Fig. | Reference, 1829. | Reference, 1874. | In what Collection. |
|---|---|---|---|
| 8. | *Nucula complanata* (cast) ...... | *Leda* ...................... | Author. |
| 9. | *Sanguinolaria elegans* ........ | *Myacites* .................... | York. |
| 10. | (*Conularia quadrisulcata*, from Coalbrook Dale, though said to be from Whitby.) | *Trigonia literata*, replacing *Conularia*. | Author. |
| 11. | *Actæon* .................... | ................ | York. |
| 12. | *Rostellaria* ? ................ | ................ | " |
| 13. | *Plagiostoma pectinoïdeum* (a small specimen). | *Lima* ...................... | " |
| 14. | Variety of *Inoceramus dubius* .. | ................ | Author. |
| 15. | *Ammonites crassus* (variety with tubercles). | ................ | York. |
| 16. | *Nautilus astacoides*, Young and Bird (*N. lineatus* ?, Min. Conch.). | ................ | " |
| 17. | *Ammonites balteatus* .......... | ................ | Whitby. |
| 18. | *Nautilus annularis* ............ | ................ | " |
| 19. | *Ammonites heterogeneus* ........ | ................ | " |
| 20. | *Belemnites tubularis*, in three portions (compressed at each end). | ................ | York. |
| 21. | *compressus* .............. | ................ | " |
| 22. | *Ammonites crenularis* .......... | ................ | " |

## PLATE XIII.—Upper Lias Shale.

| | | | |
|---|---|---|---|
| 1. | *Ammonites vittatus* ............ | ................ | York. |
| 2. | *heterophyllus* ............ | ................ | " |
| 3. | *subcarinatus* ............ | ................ | " |
| 4. | *sigmifer* ................ | ................ | Author. |
| 5. | *Conybeari* ?, jun. ........ | ................ | York. |
| 6. | *Lythensis* ............. | ................ | " |
| 7. | *exaratus* ............... | ................ | " |
| 8. | *Hawskerensis* ............ | *Ammonites spinatus* .......... | " |
| 9. | *arcigerens* ............. | ................ | Ripley. |
| 10. | *ovatus* .................. | *Ammonites opalinus* .......... | York. |
| 11. | *maculatus* ............. | ................ | " |
| 12. | *elegans* ? ................ | ................ | " |
| 13. | *erugatus* ................ | ................ | Bean. |

## Marlstone and Ironstone Series.

| | | | |
|---|---|---|---|
| 14. | *Cardium truncatum* .......... | ................ | York. |
| 15. | *Pholadomya obliquata* ........ | ................ | " |
| 16. | *Pullastra antiqua* ........... | *Cardinia* .................... | Bean. |

## PLATE XIII.—Marlstone and Ironstone Series (*continued*).

| Fig. | Reference, 1829. | Reference, 1874. | In what Collection. |
|---|---|---|---|
| 17. | Spine of *Cidaris* | ................ | Williamson. |
| 18. | *Turbo undulatus* | *Pleurotomaria* | Bean. |
| 19. | *Ammonites anguliferus* | ................ | York. |
| 20. | *Ophiura Milleri* | *Ophioderma* | " |
| 21. | *Cardium multicostatum* | ................ | Bean. |
| 22. | *Terebratula triplicata* | *Rhynchonella* | York. |
| 23. | *resupinata* | ................ | " |
| 24. | *bidens* | *Rhynchonella* | " |
| 25. | *acuta* | " | " |

## PLATE XIV.—Marlstone Series.

| | | | |
|---|---|---|---|
| 1. | *Sanguinolaria vetusta* | ................ | Bean. |
| 2. | *Modiola scalprum* | ................ | York. |
| 3. | *Avicula cygnipes* | ................ | " |
| 4. | *inæquivalvis* | *Avicula novem-costæ* | " |
| 5. | *Pecten sublævis* | ................ | " |
| 6. | *Ammonites Clevelandicus* | *Avicula margaritatus* | " |
| 7. | *Gryphæa depressa* | ................ | " |
| 8. | *Dentalium giganteum* | ................ | " |

## Lower Lias Shale.

| | | | |
|---|---|---|---|
| 9.* | *Ammonites geometricus* | ................ | Ripley. |
| 10. | *Natica* | ................ | York. |
| 11. | (*Trigonia literata* removed to Pl. XII.) | *T. Lingonensis*, replacing *T. literata*. | Williamson. |
| 12. | *Corbula cardioïdes* | *Unicardium* | Bean. |
| 13. | *Ammonites Bucklandi*, jun. | ................ | York. |
| 14. | *Turneri?* | ................ | " |
| 15. | *Plicatula spinosa* | ................ | " |
| 16. | *Serpula capitata* | ................ | Bean. |
| 17. | *Pinna folium* | ................ | York. |
| 18. | *Plagiostoma* | *Lima* | Bean. |

## PLATE XV.—Section of the Cliffs in the Southern Part of Holderness.

These cliffs are composed of drifted clays, sands, and gravels, with several freshwater deposits at different levels. A shell-bed occurs at the foot of Dimlington Height.

## Plate XVI.—Section of the Cliffs in the Northern Part of Holderness.

These cliffs have the same general characters as those already noticed, the low-level freshwater deposits at Hornsea and Skipsea, and others at a higher level south and north of Bridlington, being very remarkable. Immediately north of Bridlington Harbour the shell-beds, formerly known as "Crag," occur.

## Plate XVII.—Section of the Cliffs between Bridlington and Filey.

The part of this Plate which contains the Red Chalk and Speeton Clay is reengraved, to agree with the modern views of these deposits.

## Plate XVIII.—Section of the Cliffs from Filey to Haiburn Wyke.

This Plate is for the most part redrawn and reengraved, to exhibit more exactly the subdivisions of the oolitic beds between the Cornbrash and the Lias, with the triple series of shales, sandstones, and ironstones, which are included.

## Plate XIX.—Section of the Cliffs from Haiburn Wyke to Sandsend.

This Plate has been in part reengraved, to represent more correctly the general succession of beds in Stainton-dale Cliff, and some other points of lesser importance.

## Plate XX.—Section of the Lias Cliffs between Sandsend and Saltburn.

No material alterations have been made in the lines of this Plate.

## Plate XXI.—Section of the Coast between Saltburn and Redcar.

The beds of Lower Lias have been introduced at Redcar, which were omitted in previous editions, as being below the high-water line.

## Plate XXII.—Enlarged Sections.

These remain as they were; but fresh drawings of several appear in the text.

## Plate XXIII.—Enlarged Sections.

These are left as they were formerly given; but more complete vertical sections of the Lias are given in the text, and more exact longitudinal sections across the Vale of York.

## Plate XXIV.—*Williamsonia (Zamia) gigas.*

Fig.
1. Male organ, verticillate bracts (involucrum), seen basally.
2. Male organ, verticillate bracts, seen laterally.
3. Female organ, a verticil of fruit-bearing bracts ("carpellary disk"), seen basally. *b* represents the coalesced bases of the verticil of bracts, *c* their free portion.
4. Male organ, seen laterally.
5. " the bracts expanded, seen basally.

*Note.*—See pages 224 & 225. The letter *a* refers to the vascular axis or stem; *b*, the bracts; *c*, a layer of elongated cells or cavities.

## Plate XXV.—Belemnitidæ of the White Chalk, Red Chalk, Kimmeridge Clay, and Coralline Oolite.

1. *Belemnitella mucronata* .... W. C.
2. *granulata* ............ "
3. *Listeri* .............. R. C.
4. *minimus* ............ R. C. Neoc.
5. variety .............. " "
6. *attenuata* ............ " "
7. *Belemnites jaculum*, showing the limited groove (thus resembling *Belemnitella*) and the decaying laminæ about the apex of the phragmocone, by which the form of "actinocamax" of Miller is produced in this species and in the *Belemnitellæ* of the Lower Chalk and Upper Greensand.
8. *Belemnites lateralis*, showing the outlines at different stages of growth. The innermost outline corresponds to what has been called *B. semisulcatus*, &c. of Brongniart.

8*a*. The cross section at the alveolar apex.

9. *Belemnites Juddii*, a long Belemnite from Speeton, in the possession of Mr. Lee. It agrees nearly with a species found in the Kimmeridge Clay near Oxford. G. A. The cross section is somewhat oval. This species is included in Mr. Judd's list under the name of *B. lateralis*, Phill.
10. *Belemnites abbreviatus*. Cor. Ool.

## Plate XXVI.

1. *Belemnites Owenii.*
2. *tornatilis.*
3. 4. 5. } *hastatus.*
6. *anomalus.*
7. *quinquesulcatus.*
8. 8*a*. 8*b*. } *Belemnites quinquesulcatus.*
9. 9*a*. 9*b*. } *Aalensis.*

## PLATE XXVII.



## PLATE XXVIII.

# INDEX.

THE END.

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RED LION COURT, FLEET STREET.

PLATE I.

# CHALK.

## SPEETON CLAY.

Drawn by J. Phillips.

Dawson & Brown sc. York.

SPEETON CLAY. PL. 2.


Drawn by J. Phillips. Engraved by Dawson & Brown.

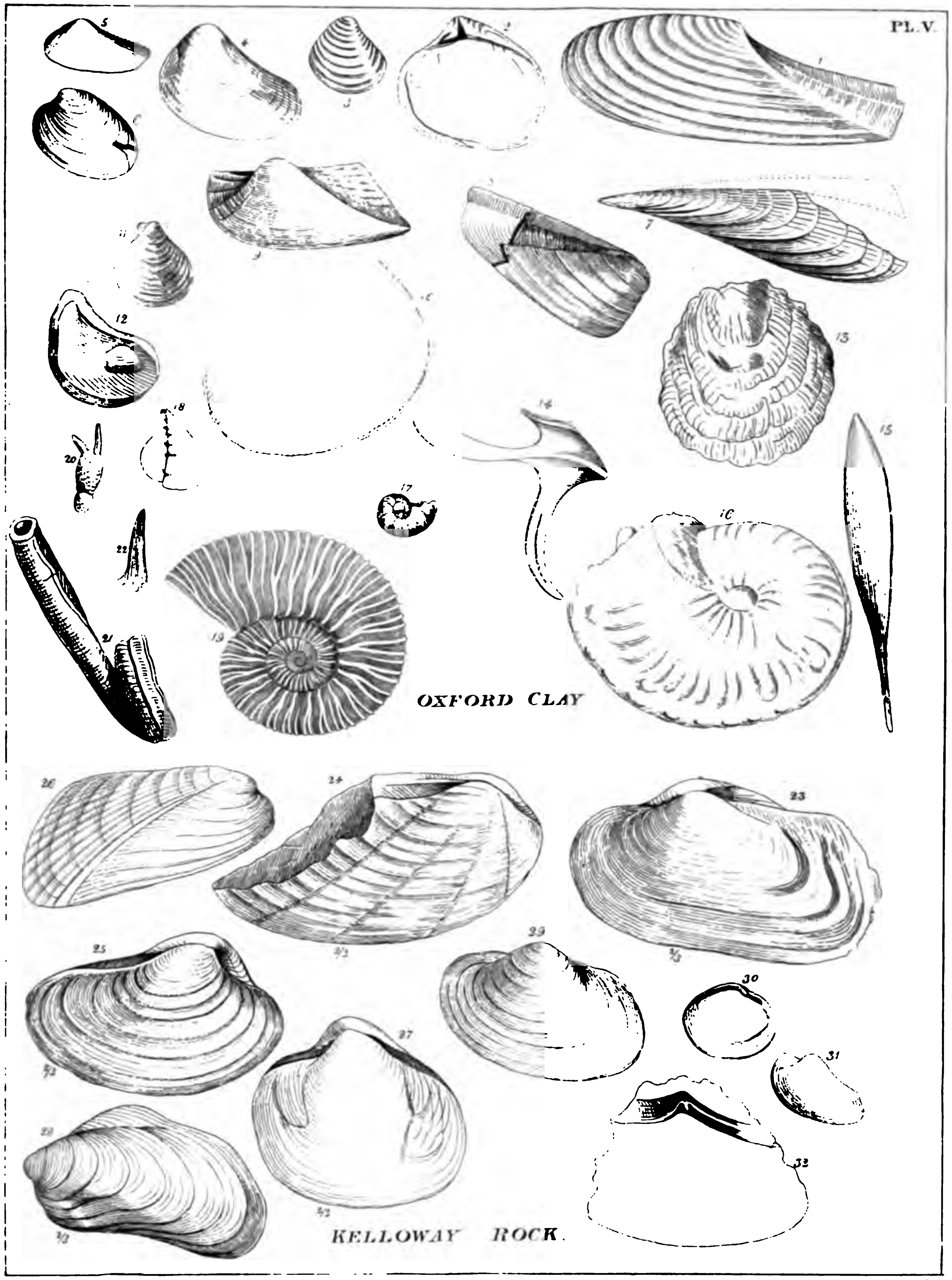

SPEETON CLAY.
PL. 2.
Kimm. Clay
Drawn by J. Phillips.
Engraved by Danton & Brown.

SPEETON CLAY. PLATE 3.


Drawn by J. Phillips. Dawson & Brown York

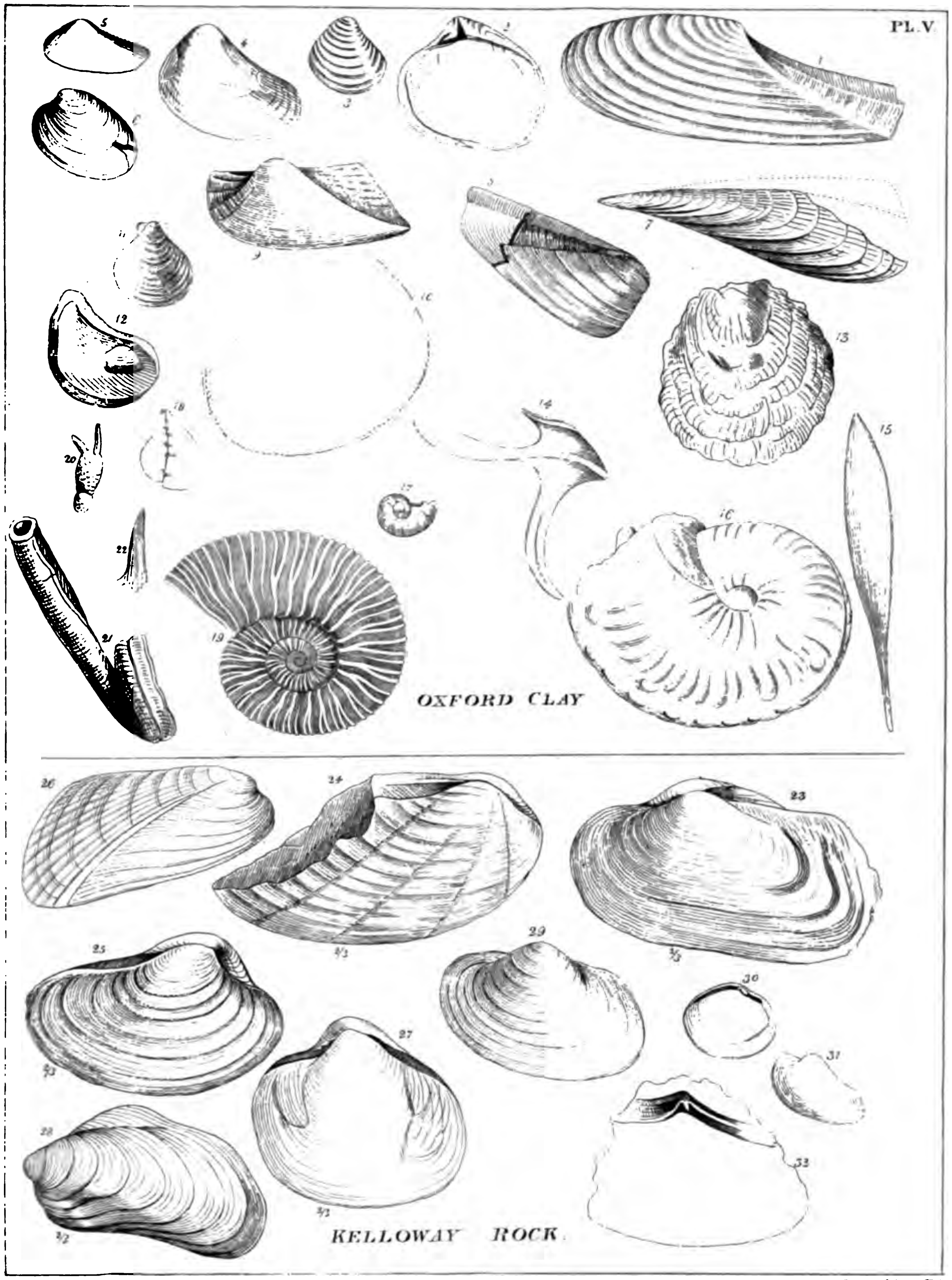

Drawn by J. Phillips. Dawson & Brown, sc. York.

PL. V.




Drawn by J. Phillips

Dawson & Brown York



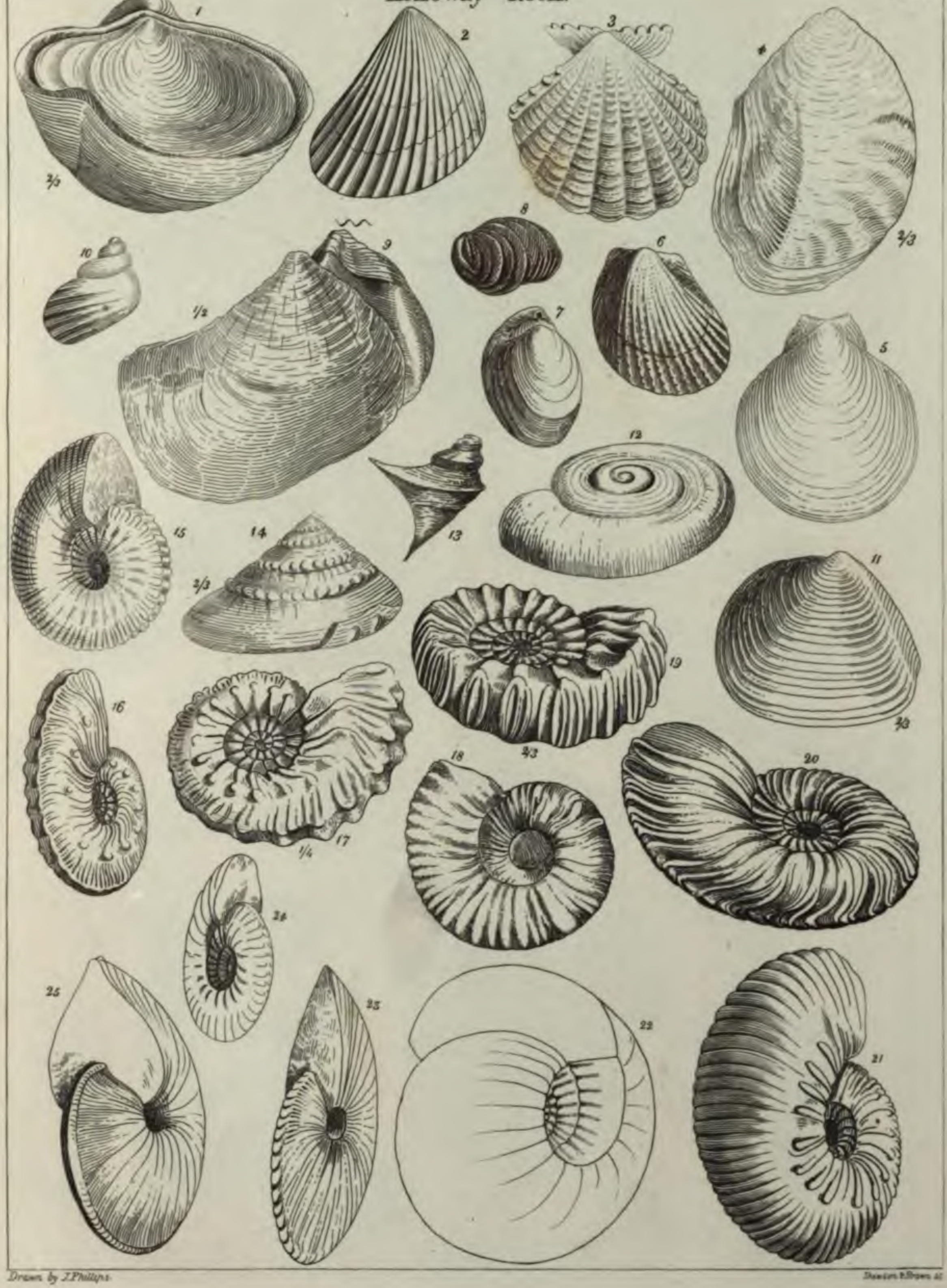

Drawn by J. Phillips

Dawson & Brown York


Drawn by J. Phillips.

Dawson & Brown, sc. York.

## Kelloway Rock. PL. 6




Drawn by J. Phillips. Dawson & Brown sc.

Cornbrash.

PL. 7.

Middle Sandstone, Shale and Coal.

Drawn by J. Phillips.

Dawson & Brown, sc.

Middle Sandstone Shale & Coal.

PL. VIII.


Drawn by J. Phillips.

Dawson & Brown sc.

GRAY LIMESTONE, & MILLEPORE OOLITE. PL. IX.

Drawn by J. Phillips. Dawson & Brown. sc. York.

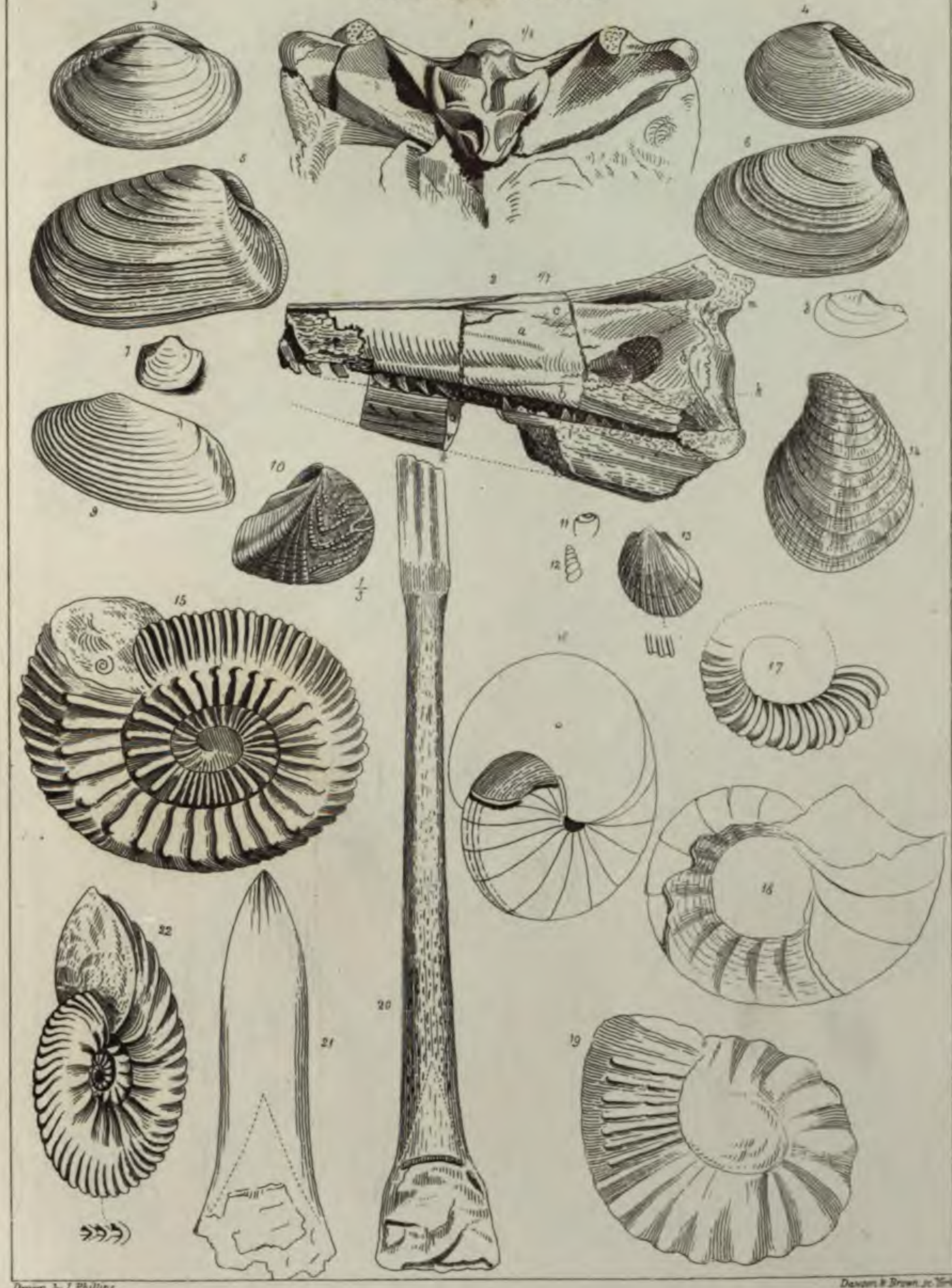
Lower Sandstone, Shale, & Coal. PL. X.

*Drawn by J. Phillips.* *Dawson & Brown sc.*

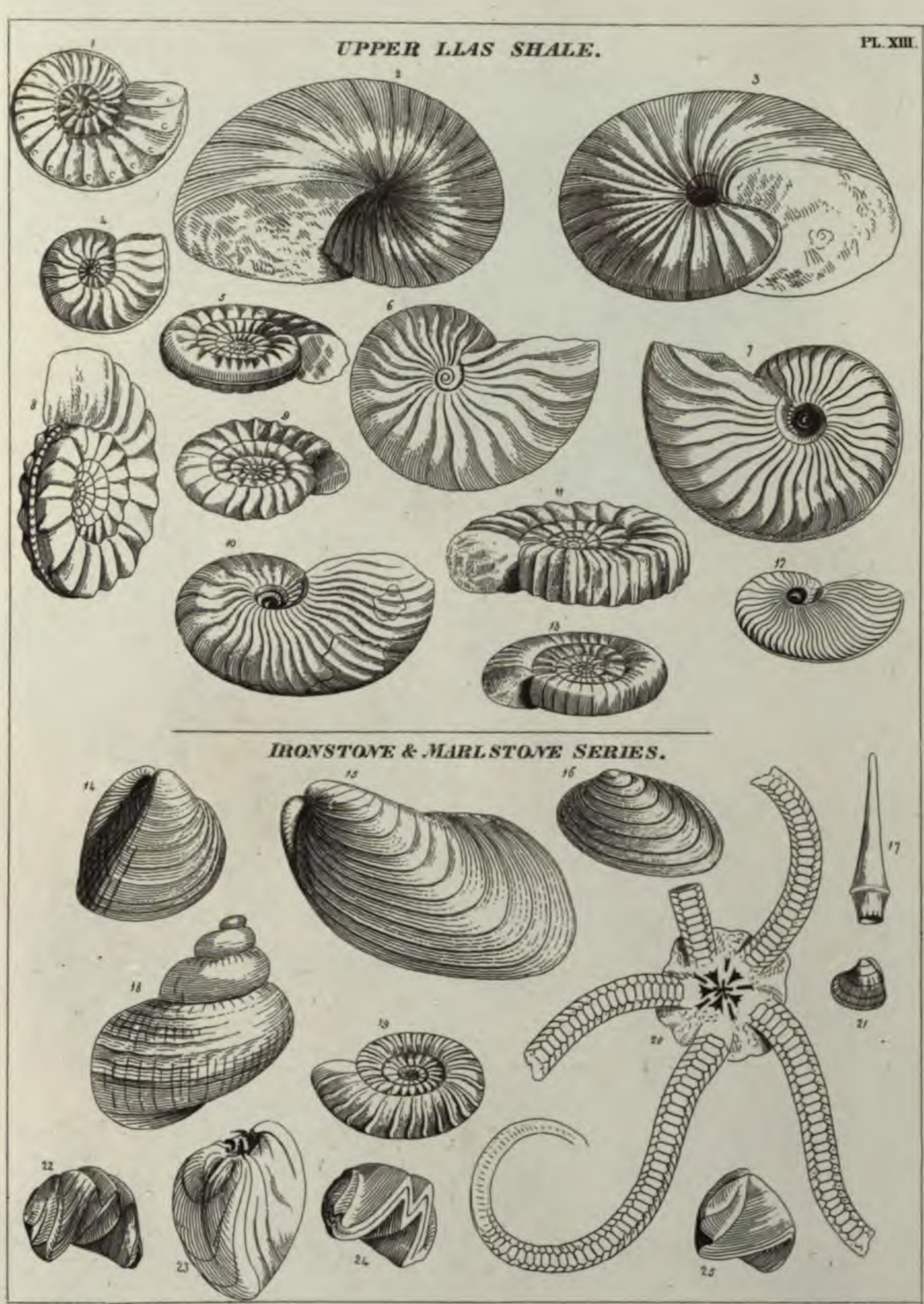
INFERIOR OOLITE (Dogger) PL. XI.

Drawn by J. Phillips. Dawson & Brown sc. York.

UPPER LIAS SHALE. PL. XII.



Drawn by J. Phillips. Dawson & Brown sc. York.




Drawn by J. Phillips.

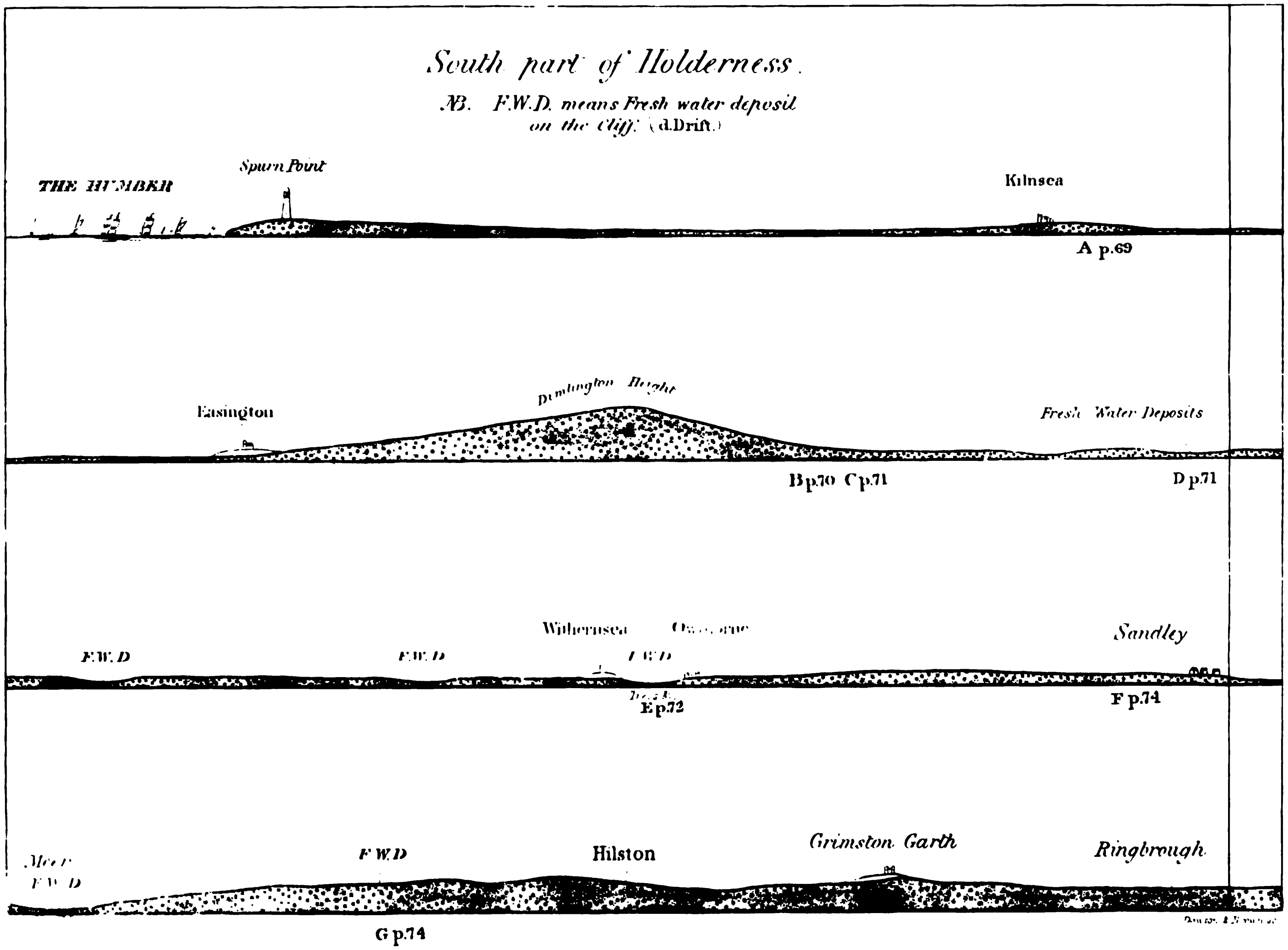
Dawson & Brown sc York.

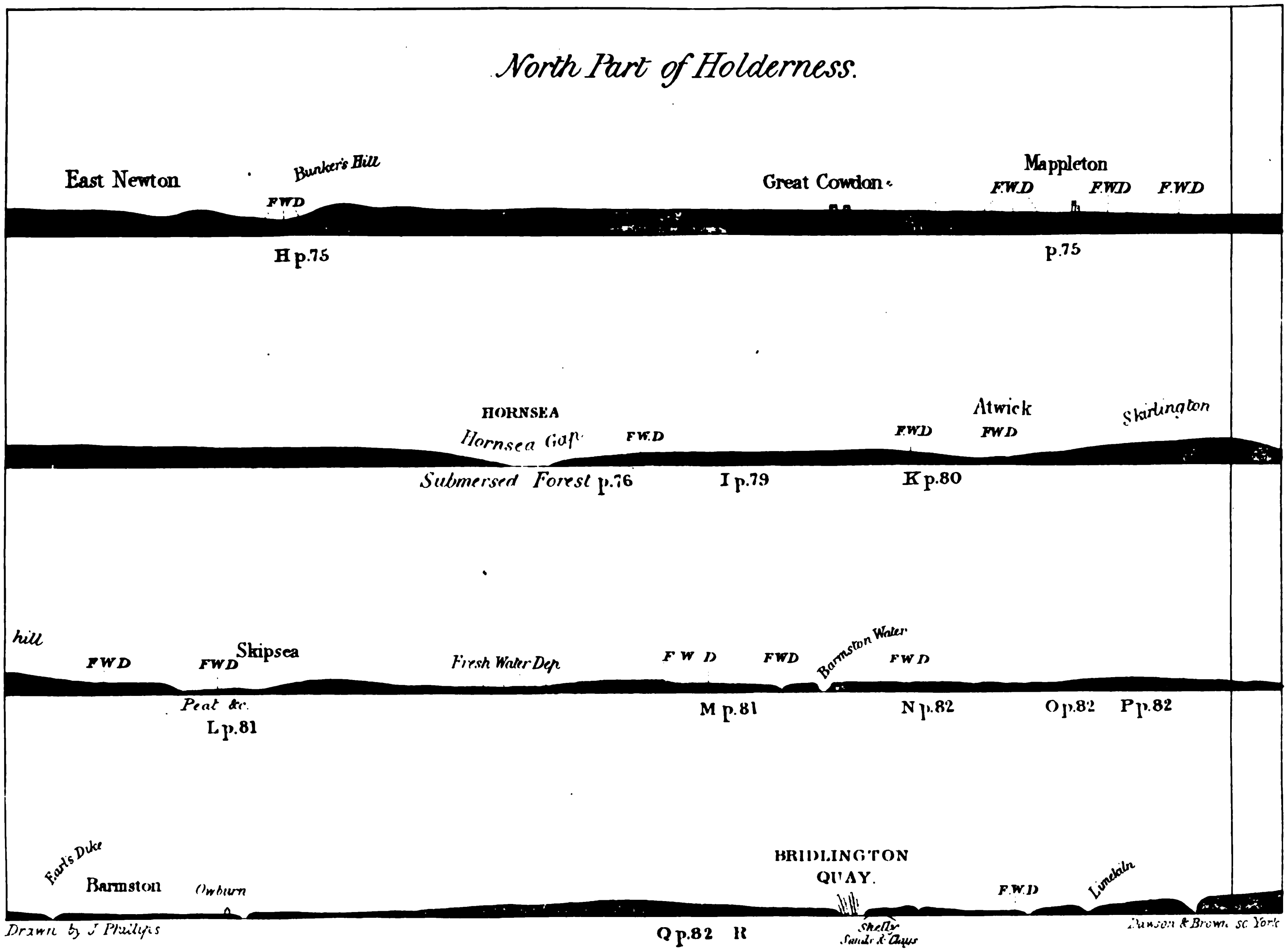
MARLSTONE SERIES. PL. XIV.


Drawn by J. Phillips. Dawson & Brown sc.

SECTION OF THE CLIFFS on the COAST OF YORKSHIRE.

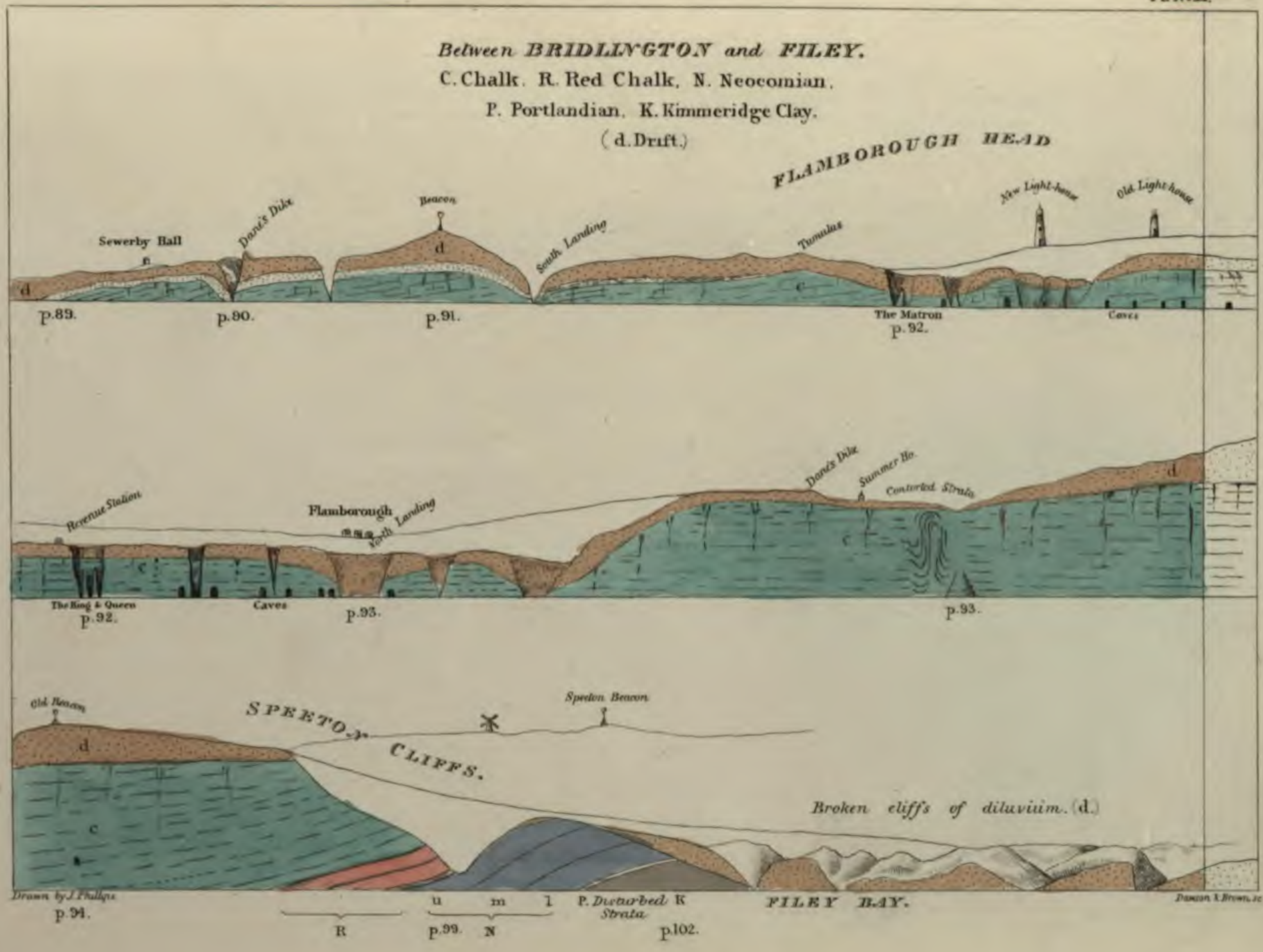
Pl. XV.



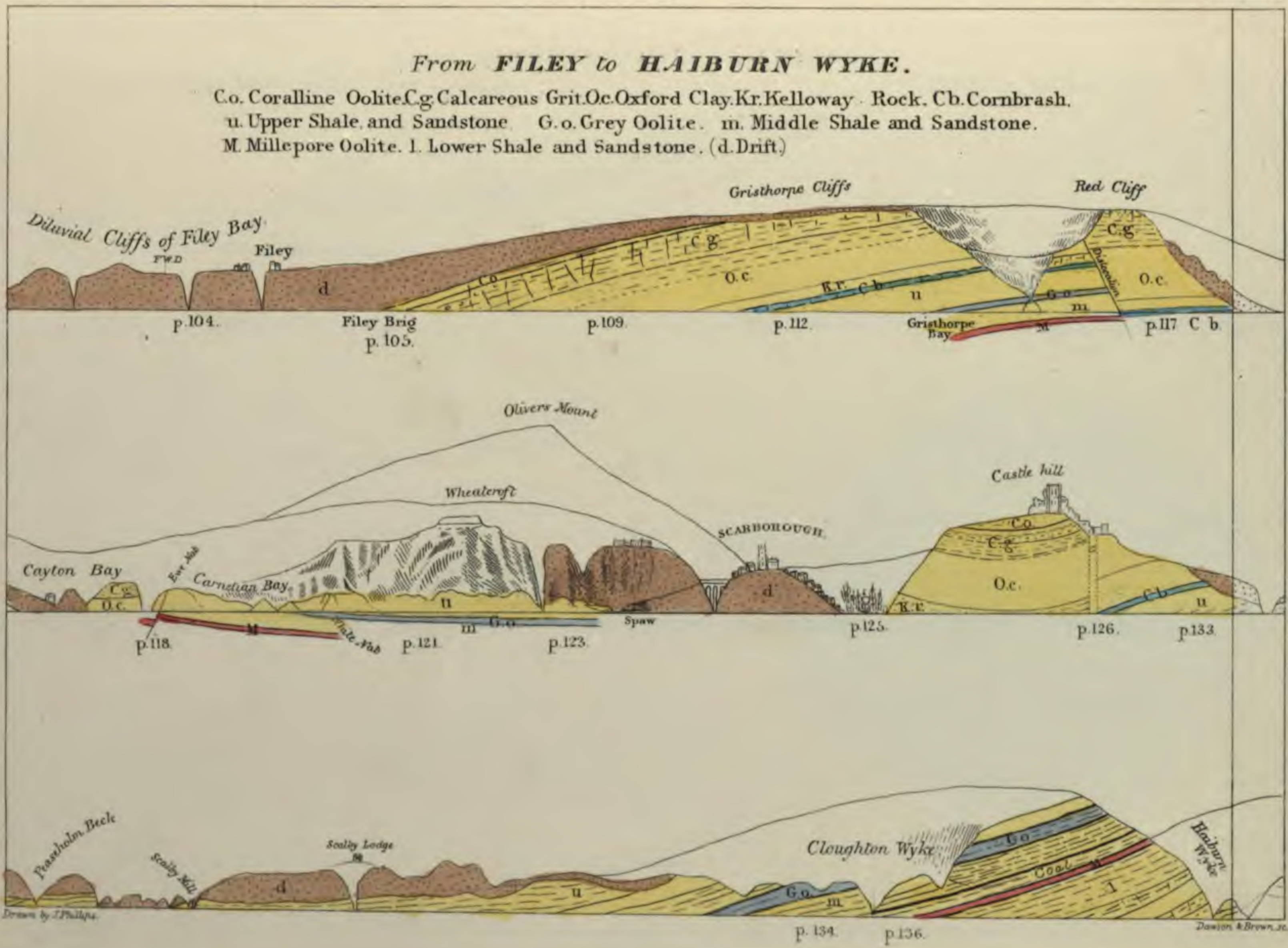


Drawn by J. Phillips

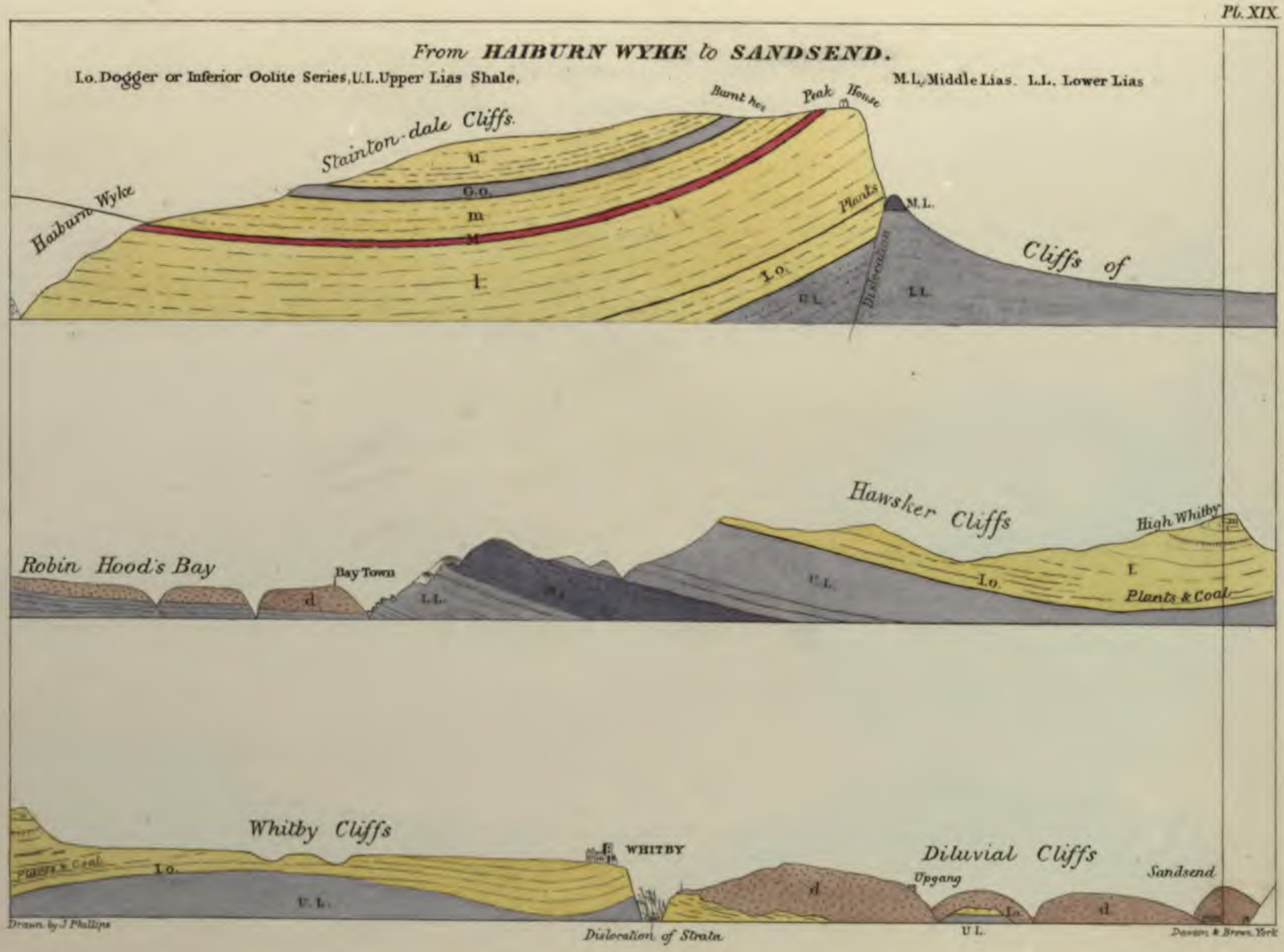
Dunson & Brown sc. York


Between BRIDLINGTON and FILEY.
C. Chalk. R. Red Chalk. N. Neocomian.
P. Portlandian. K. Kimmeridge Clay.
(d. Drift.)
FLAMBOROUGH HEAD
Sewerby Hall
Dane's Dike
Beacon
South Landing
Tumulus
New Light-house
Old Light-house
The Matron
Caves
p.89.
p.90.
p.91.
p.92.
Revenue Station
Flamborough
North Landing
Dane's Dike
Summer Ho.
Contorted Strata
The King & Queen
p.92.
Caves
p.93.
p.93.
Old Beacon
SPEETON CLIFFS.
Speeton Beacon
Broken cliffs of diluvium. (d.)
Drawn by J. Phillips
p.94.
R
u m l
p.99. N
P. Disturbed K
Strata
p.102.
FILEY BAY.
Dawson & Brown, sc.

Pl. XVIII.

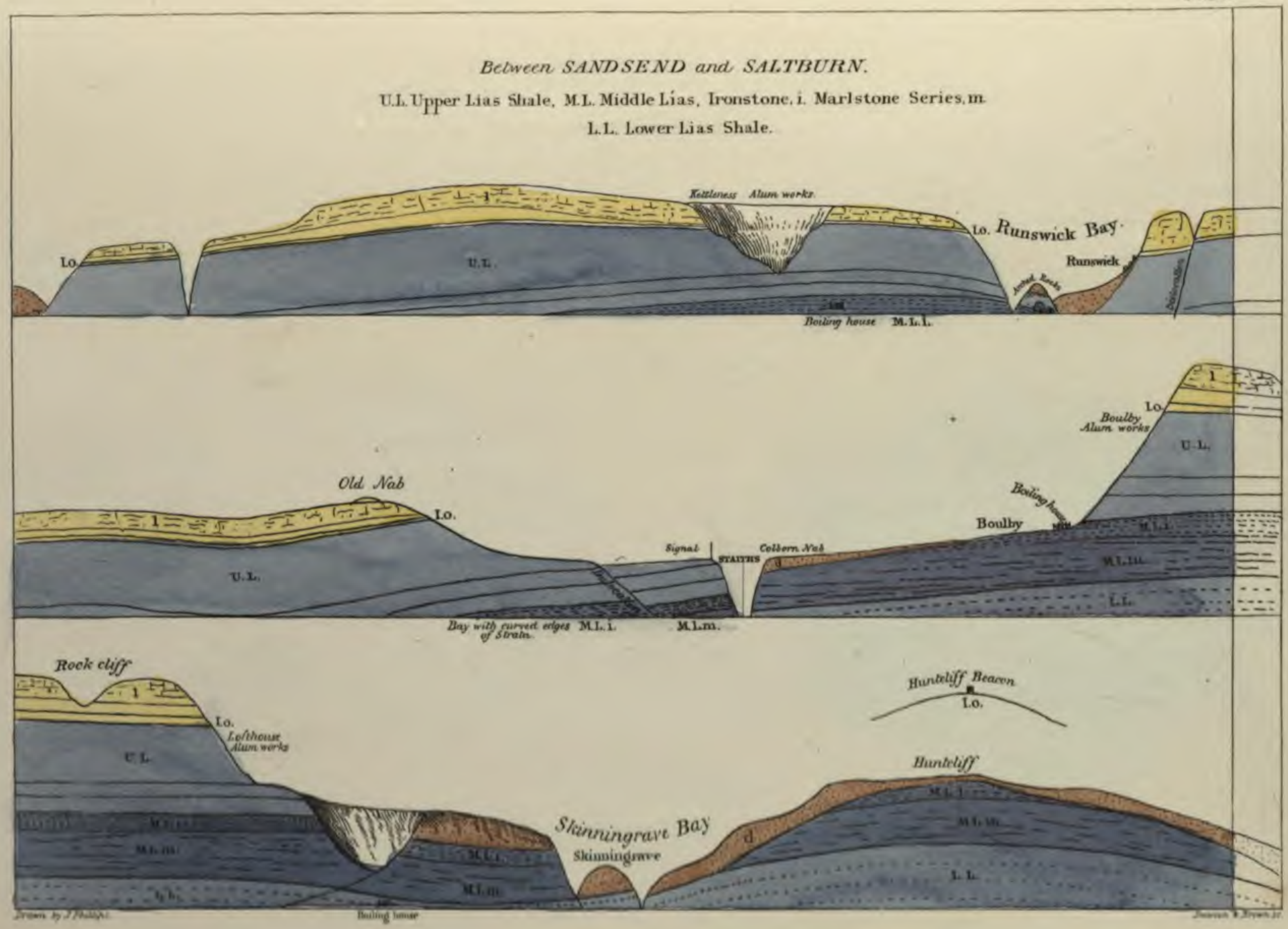

From FILEY to HAIBURN WYKE.
Co. Coralline Oolite. C.g. Calcareous Grit. Oc. Oxford Clay. Kr. Kelloway Rock. Cb. Cornbrash.
u. Upper Shale and Sandstone. G.o. Grey Oolite. m. Middle Shale and Sandstone.
M. Millepore Oolite. l. Lower Shale and Sandstone. (d. Drift.)
Diluvial Cliffs of Filey Bay
Filey
Gristhorpe Cliffs
Red Cliff
p. 104.
Filey Brig
p. 105.
p. 109.
p. 112.
Gristhorpe Bay
p. 117
Olivers Mount
Wheatcroft
Scarborough
Castle hill
Cayton Bay
Carnelian Bay
Spaw
p. 118.
p. 121.
p. 123.
p. 125.
p. 126.
p. 133.
Scalby Lodge
Scalby Mill
Cloughton Wyke
Haiburn Wyke
Coal
p. 134.
p. 136.
Drawn by J. Phillips.
Dawson & Brown sc.

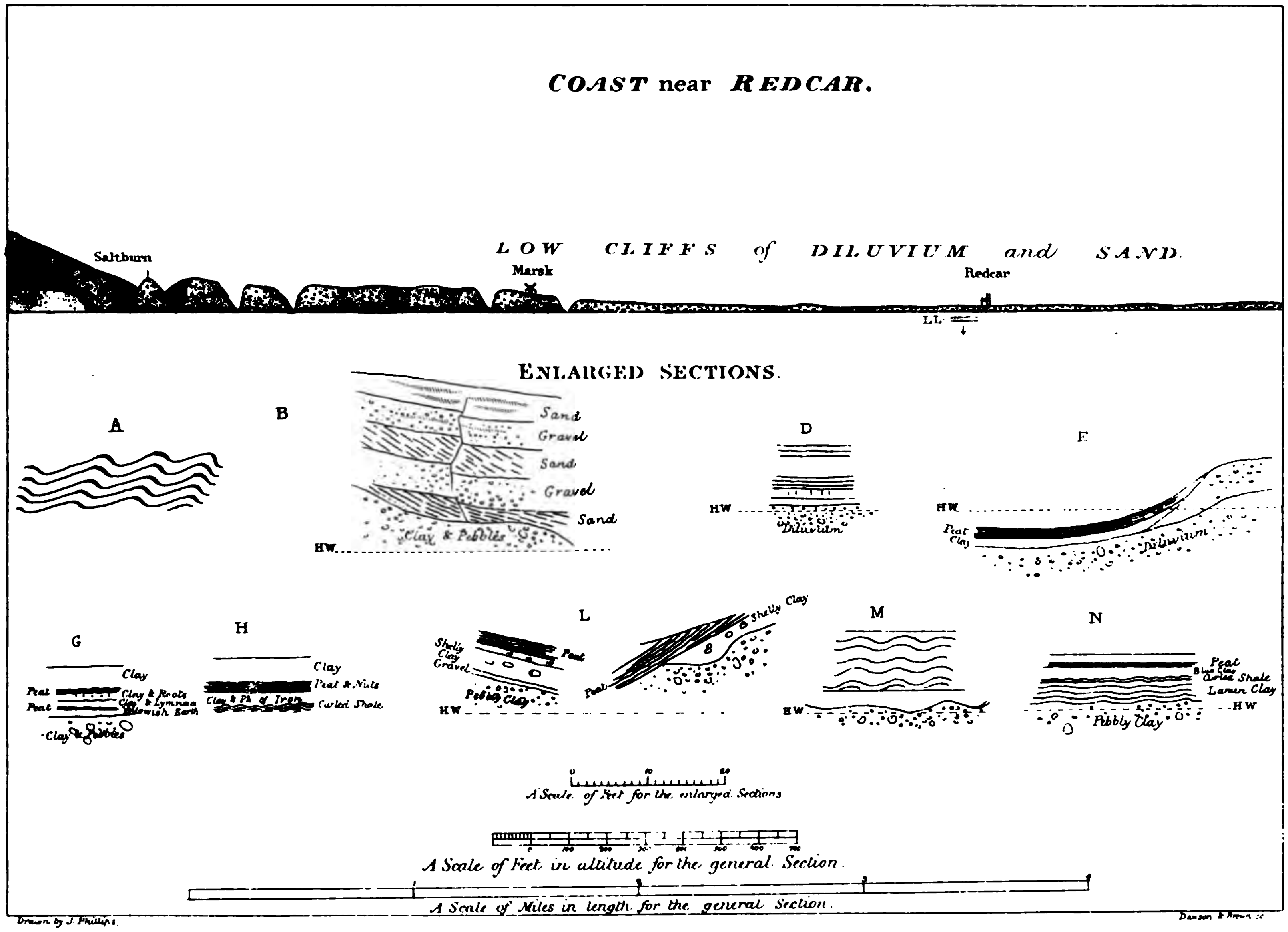
# From HAIBURN WYKE to SANDSEND.

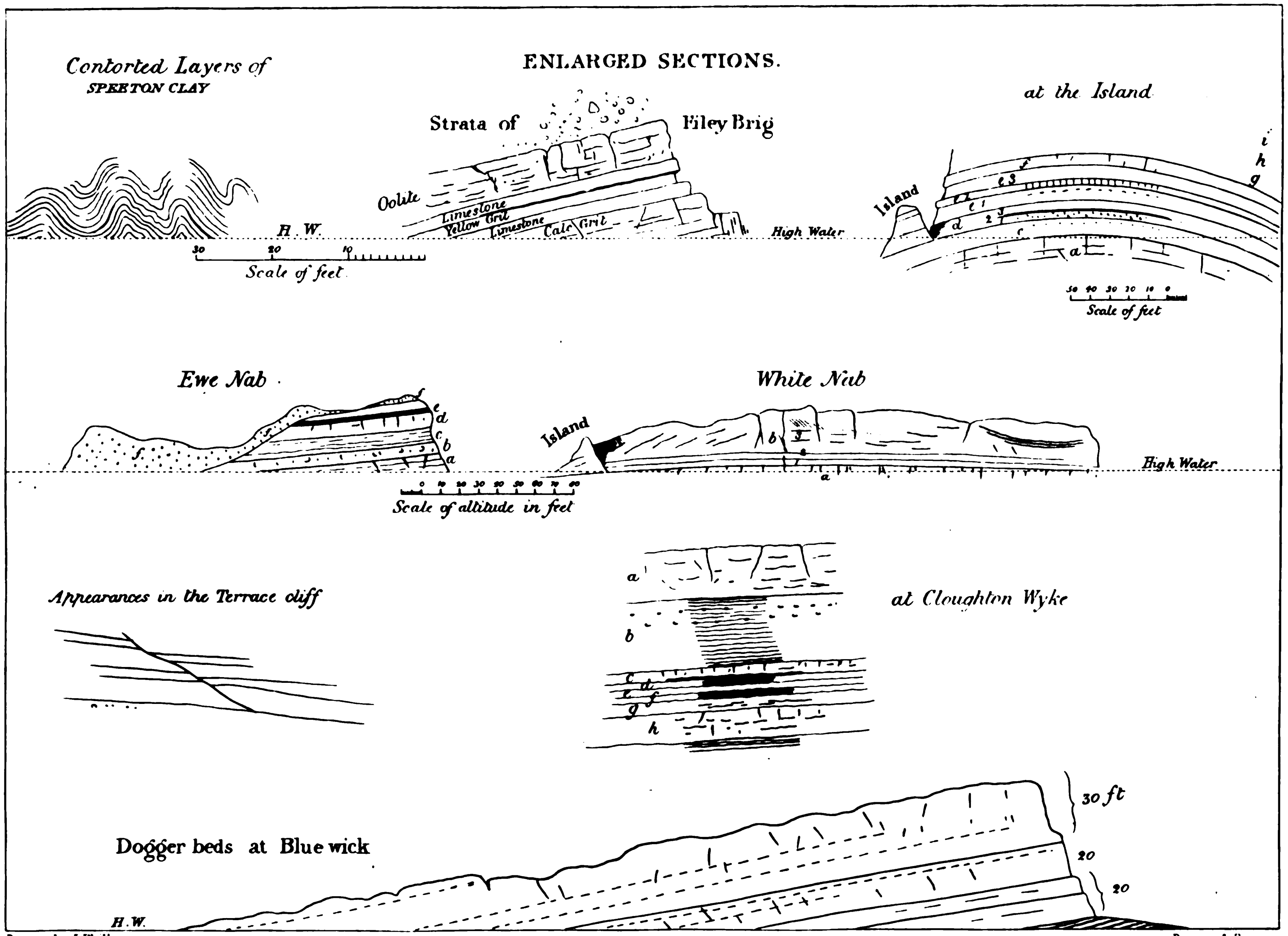



Drawn by J. Phillips

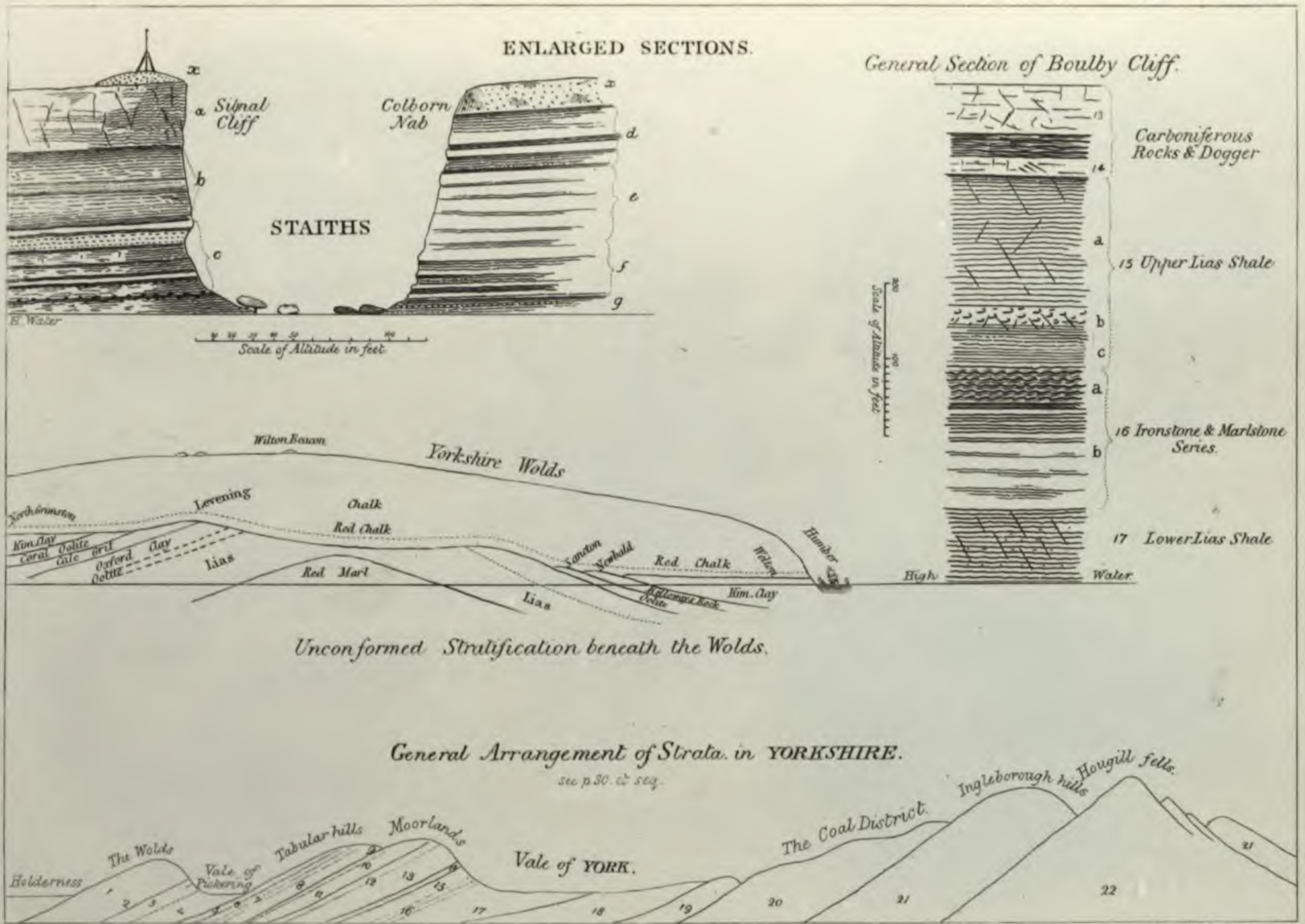
Dawson & Brown, York


Between SANDSEND and SALTBURN.
U.L. Upper Lias Shale, M.L. Middle Lias, Ironstone, i. Marlstone Series, m.
L.L. Lower Lias Shale.
Lo.
U.L.
Kettleness Alum works
Lo. Runswick Bay
Runswick
Boiling house M.L.I.
Old Nab
Lo.
U.L.
Signal
STAITHS
Colborn Nab
Boulby
Boulby Alum works
Bay with curved edges of Strata
M.L.i.
M.L.m.
L.L.
Rock cliff
Lo.
Lofthouse Alum works
U.L.
Skinningrave Bay
Skinningrave
Boiling house
Huntcliff Beacon
Lo.
Huntcliff
M.L.m.
L.L.
Drawn by J. Phillips.


COAST near REDCAR.
LOW CLIFFS of DILUVIUM and SAND.
Saltburn
Marsk
Redcar
LL
ENLARGED SECTIONS.
A
B
Sand
Gravel
Sand
Gravel
Sand
Clay & Pebbles
HW.
D
HW
Diluvium
F
HW
Peat
Clay
Diluvium
G
Clay
Peat
Peat
Clay & Roots
Clay & Lymnea
Bluish Earth
Clay & Pebbles
H
Clay
Peat & Nuts
Clay & Pk of Iron
Curled Shale
L
Shelly Clay
Gravel
Peat
Pebbly Clay
HW
Peat
Shelly Clay
M
HW
N
Peat
Blue Clay
Curled Shale
Lamin Clay
HW
Pebbly Clay
A Scale of Feet for the enlarged Sections
A Scale of Feet in altitude for the general Section
A Scale of Miles in length for the general Section
Drawn by J. Phillips.
Dawson & Brown sc.

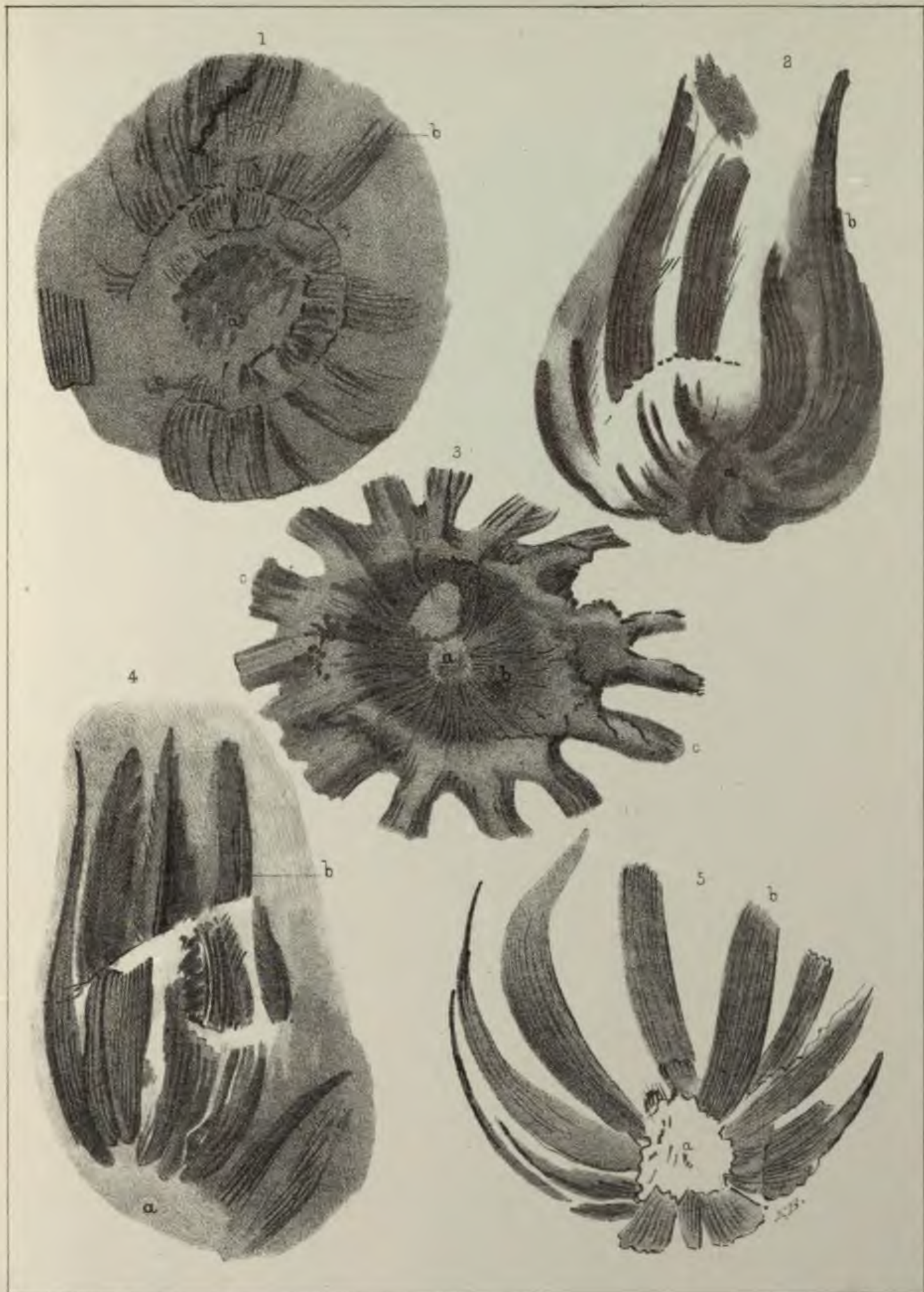



Drawn by J. Phillips. Dawson & Brown sc.



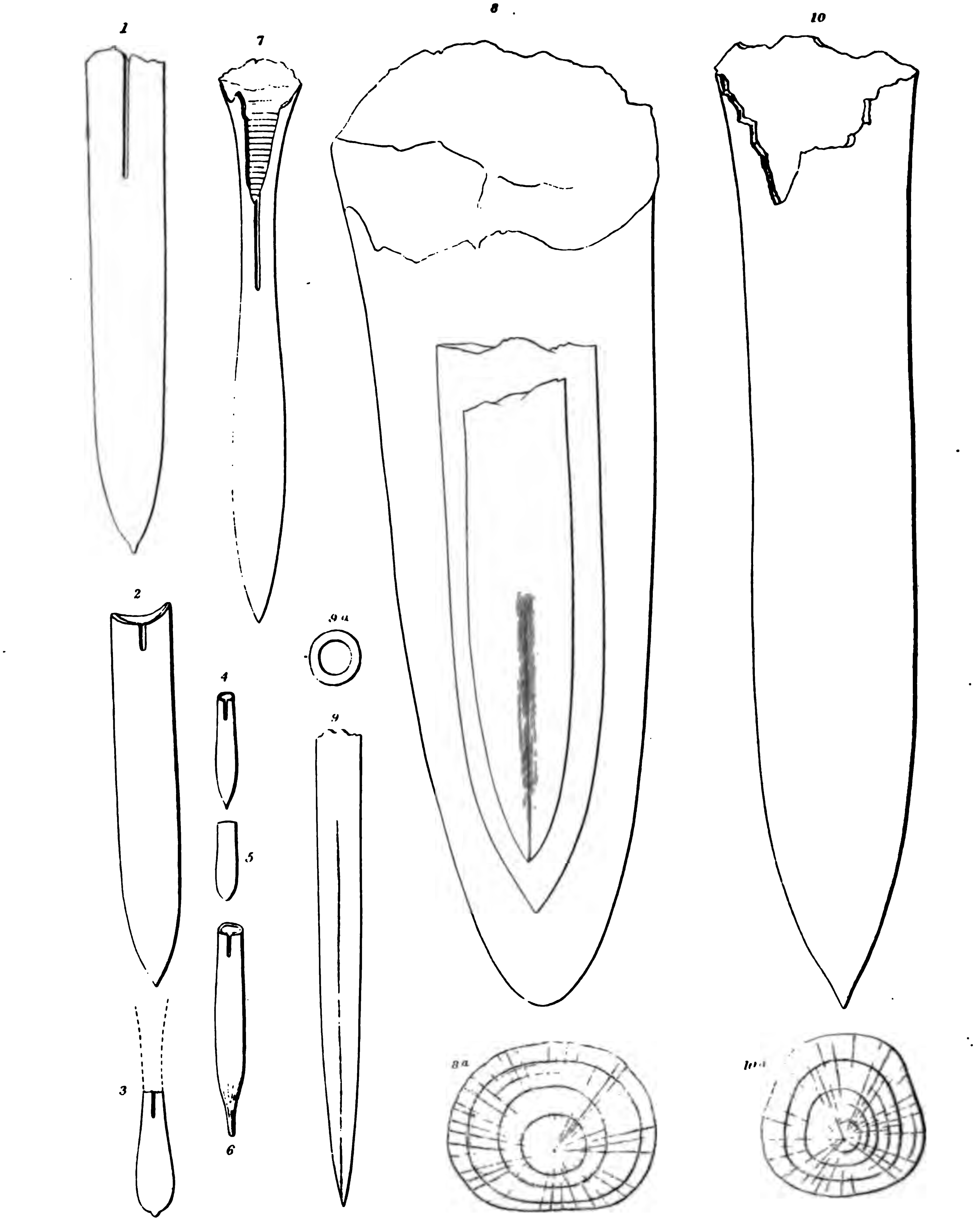

Drawn by J. Phillips.

Dawson & Brown sc. York.




Drawn by J. Phillips.

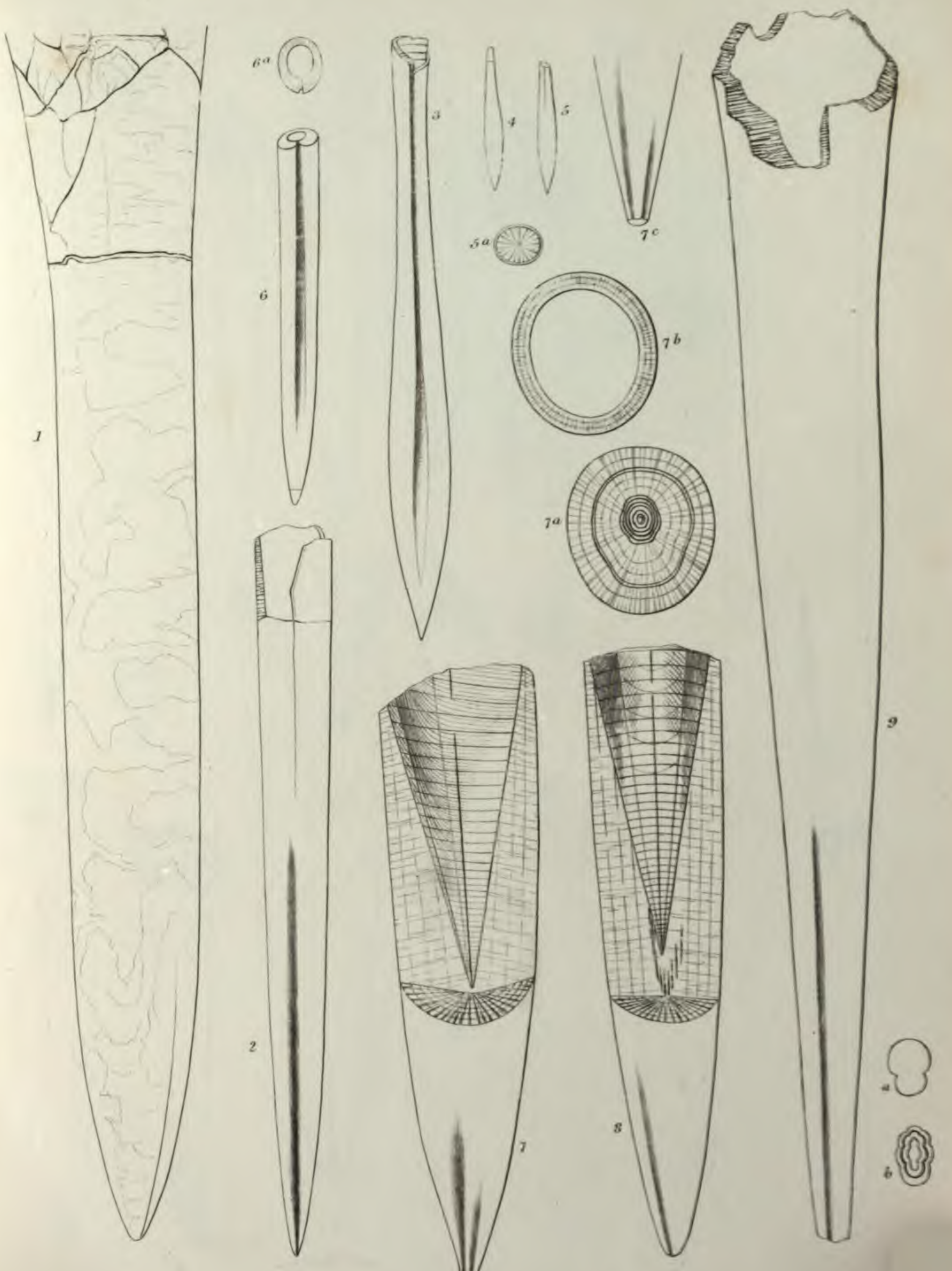
Stead & Monkhouse, lith. York.

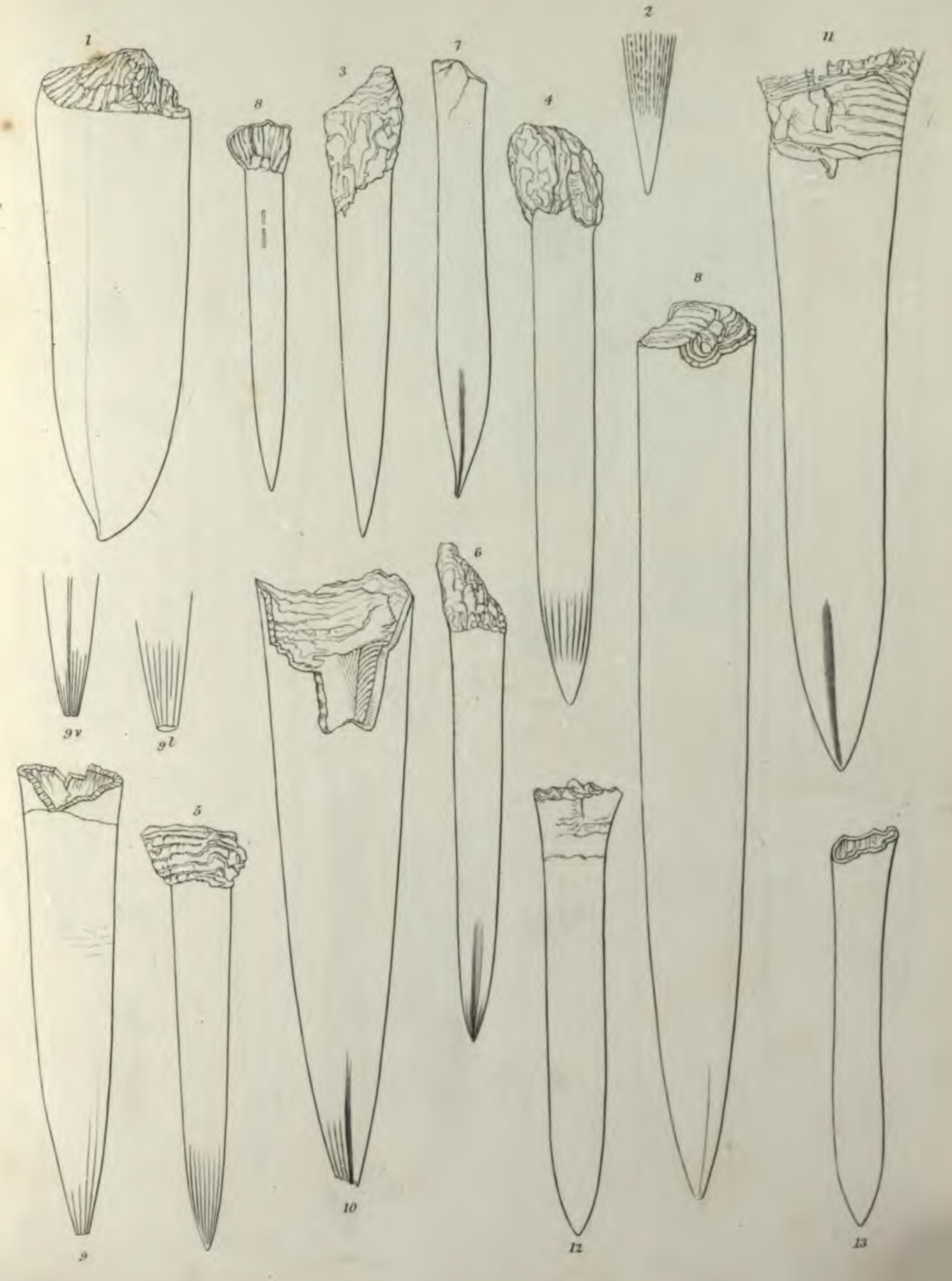



J. Phillips.
J. W. Lowry.

OXFORD CLAY, AND GREY LIMESTONE.

Pl. XXVI.






J. Phillips

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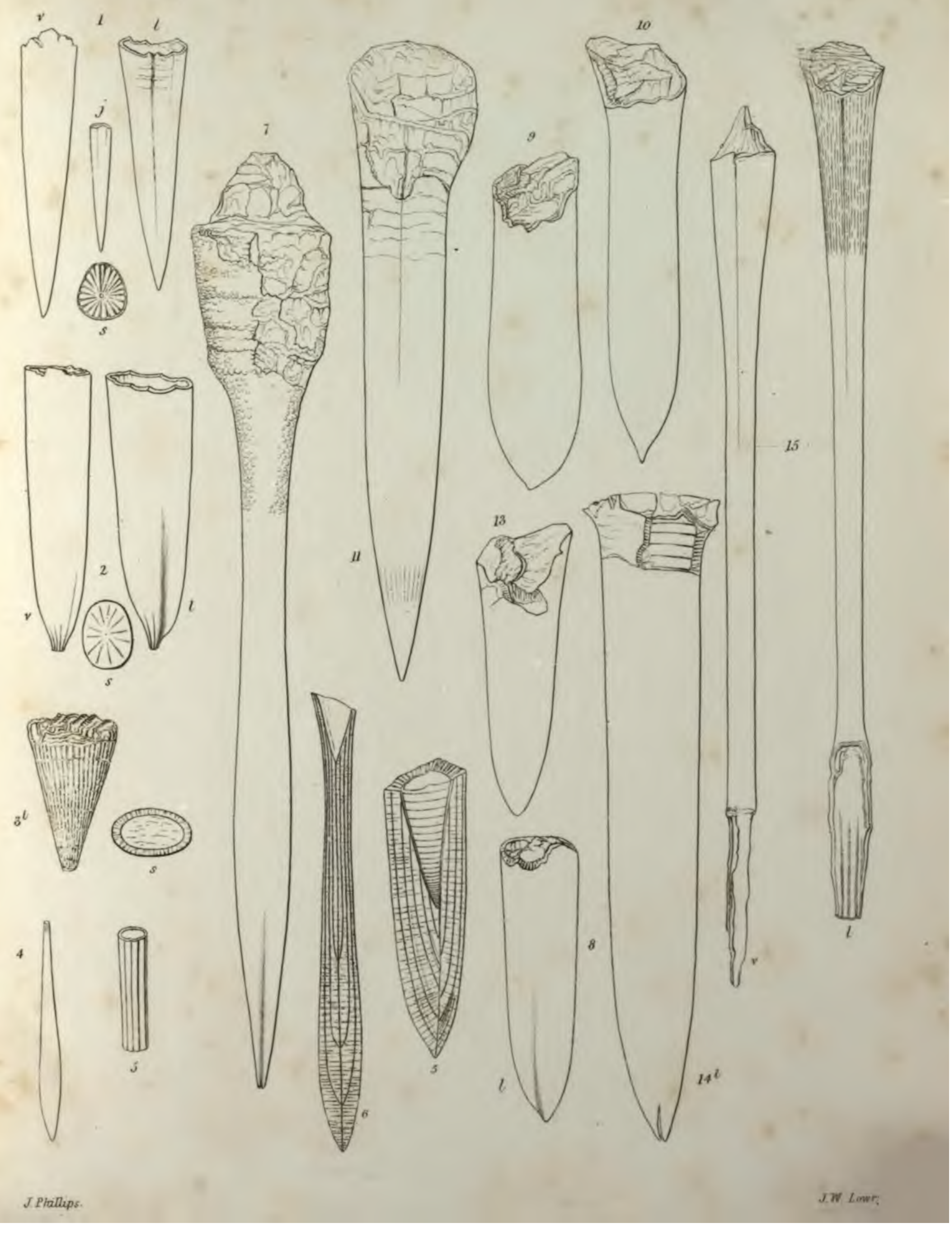

J. Phillips.

J.W. Lowry